Proceedings for the 5th International Fire Behavior and Fuels Conference
April 11-15, 2016, Portland, Oregon, USA
Published by the International Association of Wildland Fire, Missoula, Montana, USA

Landscaping with Ornamental Trees and Exterior Structure Features Using EcoSmart Fire Model

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Introduction

EcoSmartFire is a Windows program that models heat damage and piloted ignition of structures from radiant exposure to discrete tree fires. It calculates the radiant heat transfer from cylindrical shaped fires to the walls and roof of the structure while accounting for radiation shadowing, attenuation, and ground reflections. This approach is in contrast to the mainly anecdotal knowledge in various publications regarding fire protection in the Wildland Urban Interface (WUI), including the NFPA 1144, ICC WUI code, and the well regarded ANR Publication 8228: Home Landscaping for Fire (Nader, et. al., 2007). For example, Nader recommends a home defense zone, a clearance of flammable vegetation (with some exceptions) up to 30 feet from the house. In contrast, a physics-based fire risk model can allow variation on this 30 feet clearance making the landscaping adaptable to any home lot configuration. Further, Nader describes a fuel-thinning zone 30 feet (10m) to 100 feet (33m) from a house in which fuel modification limits any development of surface spread or ladder fires. However, there are alternatives to the fuel thinning such as noncombustible fencing, extending the home defense zone, removing only the forest floor litter, or using resistive structure cladding, such as a stucco wall. Within the home defense zone, the ornamental vegetation was described as being fire resistant and maintaining a spacing of 10 (3m) feet between combustible objects. This cautious approach would seem to be overly conservative if the goal of fire risk modeling is to prevent structure ignition in a worst-case scenario of simultaneously igniting the ornamental vegetation with a strong ember shower.

EcoSmartFire is still a work in progress but the physics-based model has been calibrated by comparison with selected fire tests in a previous work (Dietenberger and Boardman, 2016). Further validation and additional material properties should be added in future work. Here, the PC version is exercised to determine fire and damage risk predictions exploring the sensitivity to relevant parameters and geometric configurations. Some of these parameters were limited due to the user interface of the on-line web version (part of EcoSmart Landscapes) which shares the core fire calculation engine. The PC version runs from text files and allows full exploration of the fire program features. The parameters varied in this work are tree positioning and trimming, fire resistant exterior claddings, radiation blocking with fences and outbuildings, ground covering reflection coefficient, and flame attenuation by blocking burning trees. These program features are demonstrated using a single structural wall.

On-line ecoSmart Landscape with Fire Model for Worst Case example

The on-line fire model considers the following worst-case wildfire scenario. A large concentration of small embers serve as a pilot for tree crown fires, but not for significant direct heating of structure material. These embers cause simultaneous ignition of the stressed ornamental vegetation within the home defense and fuel thinning zones, which then radiate to the structure. Since weather conditions are not within control of the homeowner, the worst weather is assumed: dry conditions for the vegetation (moisture content at 20%), wind speed of 5.7 m/s, and ambient temperature at 25 degrees Celsius. An average ground condition of grass in the yard and dry litter surrounding the trees results in the surface reflection around 0.3. The model for calculating the tree heat release rate is primarily for pine trees, due to the available data. Extension to other tree types will need verification in laboratory tests of the species burn. For the on-line application the home is limited to 4 walls (with selection of wood or vinyl siding) and 1 flat-roof (with selection of cedar shakes or Class A asphalt shingle) for exposure of up to 9 trees burning, located anywhere and of any size on the lot.

As our test location, we choose a home in Hidden Valley Lake California. The Hidden Valley Structure Protection report describes improved fire protection using a hand crew during a wildland urban interface fire in this location http://www.wildfirelessons.net/orphans/viewincident?DocumentKey=215deac1-199c-4031-9d1e-11d9ce96939e, and provides a google map image in their Figure 7. The ecoSmart Landscape software can obtain the same map image, but we focus on a single home lot shown in Figure 1.

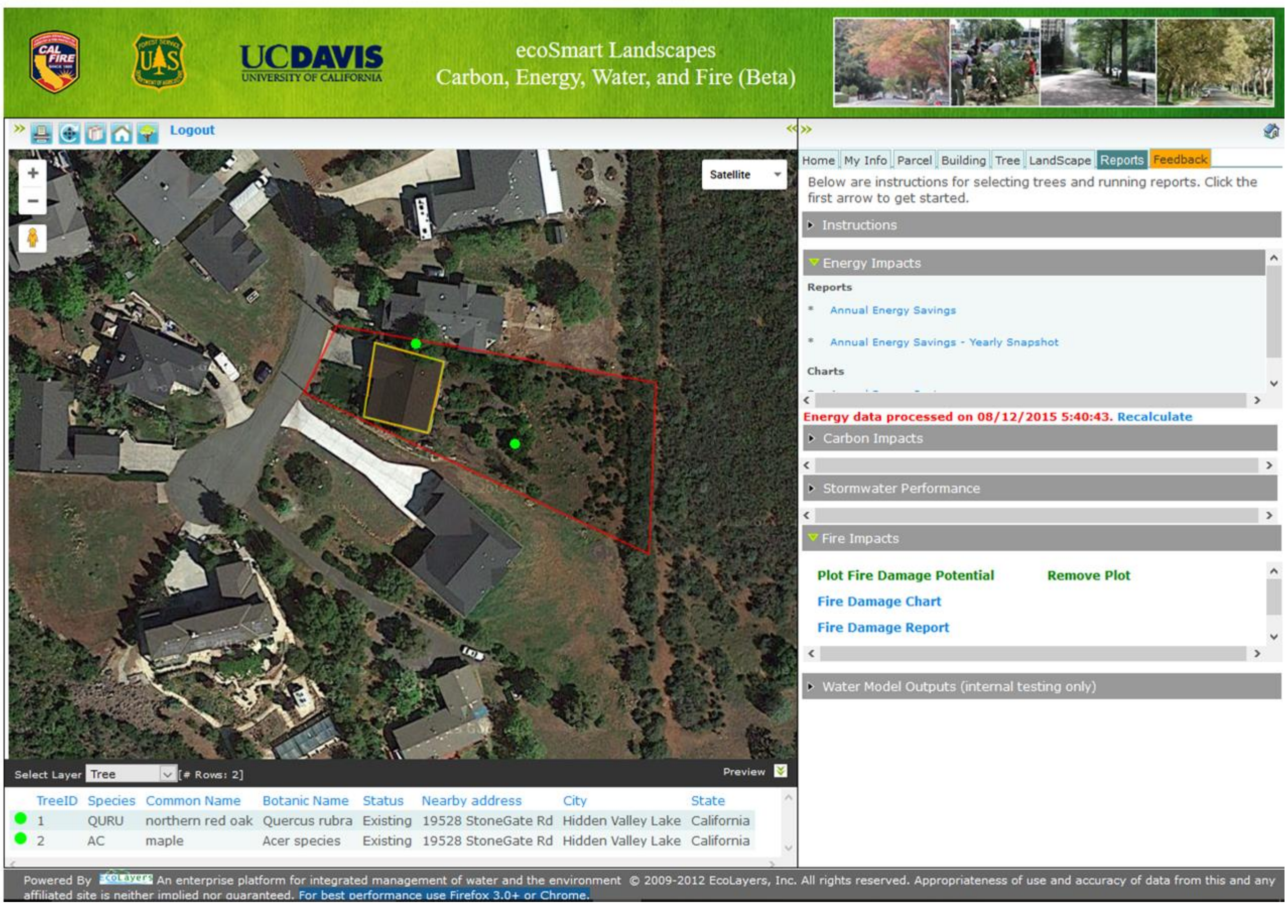

Figure 1. Output from ecoSmart Landscape for fire modeling of a Hidden Valley site.

The homeowners in the aftermath of this WUI fire may be wondering how to protect their homes better, particularly if access to active fire protection becomes limited the next time around. If they rely on anecdotal knowledge, which is available on various websites, the inclination would be the lowest cost approach, which is to first harden the homes against the embers, and secondly, to do vegetation clearance to 30 feet (10 m) and thinning in the zone beyond. This in effect would be a barren landscape if all homeowners execute this vegetation management approach. In our particular example of Figure 1, with two modeled trees placed on the lot, results indicate that the house adjacent to the burning trees would experience minimal damage to a supposed redwood siding, although not to the level of piloted ignition. Note that the criteria for both damage and ignition uses the more accurate critical temperatures rather than on the overly conservative critical heat fluxes (Dietenberger and Boardman, 2016). From this limited analysis, one might extrapolate that the ornamental vegetation can pretty much be kept intact for this and other lots, as long as the home has been upgraded where necessary to protect only against ember showers.

Physical Modeling Features of PC-based ecoSmart Fire Model

However, to consider the thinning beyond the 30 feet will require the use of the PC-based fire model that can calculate for the many trees in the zone, and provide alternate fuel loading or protection strategies that are lower cost than the continuous thinning otherwise required. In addition, the PC-based fire model has more options for structure protection (i.e. stucco siding) and ability to consider fencing or outbuilding or ground cover management, as the alternative to the thinning in the zone beyond 30 feet (10 m). The PC-based fire model allows other weather related cases, to allow other worst-case scenarios, although certain limitations still exist, such as not being able to model tilted fires in the strong winds or to model the tree-to-tree fire spread progression. These modeling enhancements would be a subject for future development of the fire model. Within the constraint of this presentation, only a single wall structure needs analyzing, in order for the reader to realize that this is a physics-based fire model, which is designed to evaluate design options enhancing passive WUI fire protection.

Trees Positioning and Trimmings

To be able to choose any number, position, and size of trees the fire model was developed to divide the exposed wall into numerous surface elements and then to combine the many radiant heat sources for predicting the surface temperature rise of each surface element. To achieve model efficiency and good accuracy, vector analysis algorithms were developed wherever possible. For this presentation, we choose an example where a homeowner values privacy of closely spaced trees, to the point that the 10 feet spacing between combustible items are eliminated. Further, the line of trees is 20 feet from the combustible wall and tree heights are assumed controlled via species selection or trimming. Note that no requirements at all are made to select fire resistant species (as the model already selects conservatively the more flammable species based on available data).

Fire Resistant Cladding on Structures

Alternatively, suppose the homeowner in the previous example again values privacy, but needs the vegetation to be within 5 or 10 feet of the wall. In that case, it may be likely that a stucco wall is appropriate for 5 feet, whereas any combustible siding might be used at the spacing of 10 feet, providing the height of trees or bushes are more controlled, probably by continuous trimming.

Radiation Blocking with Fences and Outbuildings

Further, the homeowner may have no control of combustibles beyond the lot, or that beyond the home defense zone, and greatly desires the undisturbed woodland scenery. However, fencing to block thermal radiation from an intense wildfire (assuming the structure is protected against the ember showers) should be viable. To maintain a view with a possible tall fencing, the homeowner might invest in ceramic panes for a see-through barrier to fire. The height of the fence is precisely calculated due to the high resolution of surface elements on the structure wall and of the burning multiple trees. The efficiency of radiation blocking calculations is achieved through intricate vector analysis algorithms. The example of fence radiation blocking at different heights will be presented.

Ground Covering Reflection Coefficients

If the homeowner prefers not to have fences and yet highly values the undisturbed woodland scenery, then ground cover modification and minimal trimming (i.e. just the lower branches) could be sufficient, particularly in relation to a fire resistant home. Any forest floor litter will need to be removed as the leaves have a reflection coefficient of 0.45 in comparison to a typical soil reflection of 0.2. Removal of the lowest branches should not impend the scenery, but could reduce thermal radiation from a crown fire, by both controlling spatial and temporal extent of potential crown fires. The ecoSmart fire model does calculate the crown fire size and duration, for the more accurate surface temperature rise on the structure surface. The example of varying ground cover will be presented.

Flame Attenuation by Burning Trees

Finally, one can imagine a row of trees specifically selected for their ability to attenuate the flame radiation from the next row of burning trees further back. To complete the attenuation might only require a few rows of trees. The consequences of this situation might be reduction of the fuel thinning zone from the conservative 100 feet to perhaps 50 feet, which would be much more controllable by homeowner, and also be lower cost for thinning. A physics-based fire model provides the opportunity for a fire performance-based analysis, and avoids relying on anecdotal conservative estimation of the fire risk. The example of varying tree packing on the flame attenuation of burning trees will be presented.

Summary

A physics-based fire model is recommended to supplement the generic fire protection recommendations for homeowners in the Wildland Urban Interface. Some of the features of EcoSmartFire have been demonstrated, showing the potential new flexibility afforded homeowners able to calculate the effects of tree placement and wall construction on fire risk. Further enhancements and validation to the model would be helpful to make it more useful for the general public.

References

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