MAPPING THE WILDLAND-URBAN INTERFACE AND HISTORICAL FIRE PERIMETERS TO INFORM DESIGN AND PLANNING EFFORTS IN GROWING MID-SIZED CALIFORNIA COMMUNITIES

SCHLICKMAN, EMILY
University of California, Davis, eschlickman@ucdavis.edu

1 ABSTRACT

A century of wildfire suppression, growing development at the edge of wildland, and a rapidly changing climate is increasing the risk of catastrophic wildfire in the American West. In the field of landscape architecture, designing and advocating for community and ecological resilience in response to these events has become paramount. The study outlined in this paper supports the idea that the wildland-urban interface (WUI), which is particularly vulnerable to the effects of wildfire, is where multi-scalar design and planning ideas can make a profound impact and where landscape architects can employ their expertise and become stewards of change. The study explores how descriptive geospatial mapping techniques might help communities grow and develop with wildfire in mind by positioning landscape architects as advocates for land use planning strategies that have the potential to bolster resilience. In particular, the study involves the mapping of 55 growing mid-sized communities across the state of California. A broad visual analysis of these maps revealed communities with WUI areas and a history of past wildfire events. This information was then used to formulate a new urban design studio to explore future development scenarios for one of these communities. Over the course of five weeks, students explored a new paradigm of growth for the community by focusing on two centrally-located infill sites. Findings from the study point toward a development framework for growing mid-sized California cities that are vulnerable to wildfire. The framework employs mapping to identify potential risks and to speculate about potential infill areas that are less vulnerable to wildfire and areas that promote the densification of traditionally sprawling communities.

1.1 Keywords:

Mapping, wildland-urban interface, wildfire, resilience, climate change adaptation

2 INTRODUCTION

Over the last several decades, wildfires in the western United States have increased in size, and large wildfires have become more frequent (Calkin et al., 2005; Westerling et al. 2006; Miller et al. 2009; Miller et al. 2012). This shift has been primarily attributed to local changes in the quantity of wildland fuels and human development, with climate change exacerbating these conditions (Power et al. 2008; Whitlock et al. 2008; Bowman et al. 2009; Marlon et al. 2009). In California, a century of wildfire suppression has contributed to an accumulation of wildland fuels that has, in turn, increased the risk of large and frequent wildfire events (Steel et al., 2015). Furthermore, the state has experienced significant growth in the WUI. For example, from 1990 to 2010, the WUI in California expanded from 8,732 to 10,435 square miles (Radeloff et al., 2018). In the WUI, human activity has increased the risk of ignition, and fringe development has increased community vulnerability to the effects of wildland fires (Radeloff et al., 2018). The WUI has been described qualitatively, in very general terms, as a space where humans and their development meet wildland fuel, and it has also been described quantitatively, using housing units per acre and vegetation coverage percentages as criteria (Stein et al., 2013; Radeloff et al., 2018; Radeloff et al., 2005).

2.1 Designing for Resilience

In this paper, the term “resilience” does not just refer to a system bouncing back after a wildfire disturbance; rather, it refers to how key components of a system can change—adaptive resilience—and how novel systems can be created—transformative resilience. Expanding the definition of resilience is necessary in the context of wildfire because of rapidly changing conditions and the inability to return a landscape or community back to a pre-fire state (McWethy et al., 2019).

In the field of landscape architecture, designing to increase resilience in the WUI in response to these increasingly large and frequent wildfire events has become paramount. And while landscape architects have traditionally focused on residential-scale defensible space approaches when dealing with these landscapes (Kent, 2019; Soles, 2014; Gilmer, 1994), in recent years, this role has broadened in scale and scope, both professionally and academically. The following illustrates some examples.

Professionally, there has been a rise in landscape architects engaging with this topic. For example, following the devastating 2019-2020 bushfire season in Australia, Hassell Studio published an interview focused on community resilience in the face of fire (Mullane & Kochanowski, 2020). Additionally, in 2020, Rios collaborated with the Resource Conservation District of the Santa Monica Mountains (RCDSMM) to develop a program to shift residents’ perceptions about fire safety (Rios, 2020). That same year, Design Workshop was awarded a contract to help develop a wildfire resilience and recreation master plan for Mariposa County in California (Mariposa, 2020). As one last example, SWA recently completed a project in Rancho Mission Viejo using fire resilience as a primary component of their site strategy (ULI, 2020).

Furthermore, a number of academics in the field of landscape architecture are increasingly mentoring students on the topic of wildfire, using it as a driver in studio or studying aspects of wildfire in their research programs. For example, in 2016 and 2018, two large-scale speculative student projects focused on planning for and mitigating fire risk received National ASLA awards (Duke, 2016; Toth, 2018). Furthermore, over the past two years, faculty members at a range of universities, including UC Davis, MIT, and Harvard University, have been structuring studios around the topic of wildfire. Lastly, several professors are actively engaged in wildfire-related research. This includes the work of Kelly Shannon at USC (Shannon & Kaufman, 2018), Alan Berger at MIT (Berger & Susskind, 2018), Robert Ribe, Bart Johnson, David Hulse, and Chris Enright at the University of Oregon (Hulse et al., 2016; Nielsen-Pincus et al., 2015), Travis Flohr at Penn State (Flohr, 2019; Flohr, 2017; Flohr, 2016), among others.

2.2 Purpose

The study outlined in this paper builds upon this growing body of work to speculate about the expanded role of landscape architects in building resilience to the increasing threat of wildland fire in the WUI. The study is a part of a larger project that seeks to understand how designers might modify the built environment or advocate for policies to lessen the impact of wildland fires on communities. It supports the idea that the WUI is a place where design ideas can make a profound impact and where landscape architects can effectively employ their expertise and become stewards of change (Mowery, 2021; Syphard & Keeley, 2019; Cohen, 2000). It also upholds the notion that wildland fire is a wicked problem and that resilience-building tactics must come in a range of shapes and sizes – from watershed-level strategies focused on decreasing wildland fuel loads to municipal-level strategies focused on development planning to neighborhood-level strategies focused on reducing edges to parcel-level strategies focused on the arrangement of site elements, and to planting-level strategies focused on the prioritization of fire-adapted species. Lastly, the study acknowledges that at the largest tactic scales–watershed and municipal–landscape architects must often work collaboratively with other stakeholders to advocate for change.

In particular, this study focuses on spatially analyzing growing mid-sized California communities to better understand the relationship of these communities to the WUI and historical wildfire events. It explores how descriptive geospatial mapping techniques might help these communities grow and develop with wildfire in mind by positioning landscape architects as advocates for land use planning strategies that have the potential to bolster resilience.

3 METHODS

The methodological approach for this study focused on descriptive geospatial mapping. The approach for the study was two-fold. The first part focused on a broad visual analysis of growing mid-sized communities across California and their relationship to the WUI and past wildfire events. This analysis then led to the second part of the study, which focused on analyzing one of the 55 communities.

I began part one by developing a list of growing mid-sized communities. To do this, two filters were used. The first filter was a 2018 population between 50,000 and 300,000 people, targeting mid-sized cities. This was done for two reasons. First, I wanted to compare a similar set of California cities in the study. Secondly, I wanted to focus on cities that were large enough to consider infill development and cities that were small enough not to have pursued climate action planning. The second filter was a higher-than-average population growth rate (over 7.46%) between 2010 and 2018. Both sets of data came from the US Census Bureau. This exercise resulted in a list of 55 growing communities across the state of California in descending order of population growth rate. The second step of the study involved the mapping of these 55 communities at the same scale. First, road networks in each of the growing communities were mapped to reveal existing development patterns. Data for this were extracted at a county scale from the 2019 United States Census Bureau's TIGER database. After mapping road networks, a 3-mile buffer was made around each of the 55 municipal boundaries in ArcMap. This was done because our primary focus was wildfire within the municipal boundary, and we used the buffer to account for direct fire spread and potential ember travel, primary contributors to wildfire growth and structure loss (Quarles et al., 2010). The next step of the study involved mapping WUI areas in and around the 55 municipal boundaries described above. To do this, 2010 WUI data from the University of Wisconsin Silvis Lab were employed. After mapping WUI areas, historical wildfire perimeters were mapped in and around the 55 communities. For this, data from the USGS Wildland Fire Decision Support System were used. When displaying the historical wildfire data, an overlay technique was used so that areas that had been impacted by fire more often would appear darker. The last step of this part of the study involved a broad visual analysis of the 55 maps produced to understand the relationship of these communities to the WUI and historical wildfire events. For this, communities were tabulated if they had a WUI area or historical fire perimeters within three miles of their municipal boundaries.

The second part of the study focused on analyzing one of the 55 communities with WUI areas and a history of past wildfire events. For this part of the study, the growing community of Vacaville was selected for two reasons: roughly half of Vacaville's municipal land area is designated as WUI, and the city has a history of past wildfire events. With its proximity to undeveloped wildlands to the west, a pattern of growth at its periphery, shifts in land management, and changes in the climate, the community was shown to be at risk. The Norman Fire of 2014, the Wragg Fire of 2015, the Keating Fire of 2015, and the Nelson Fire of 2018 further highlighted this susceptibility. The second reason Vacaville was selected for further study was its proximity to the University of California, Davis campus, where the urban design studio was based. By studying a site within a 30-minute radius of campus, the hope was that students would be able to visit the site over the course of the quarter to better understand the conditions of the community and its adjacent wildlands. Please note that due to COVID-19, these site visits did not occur.

4 FINDINGS AND DISCUSSION

4.1 Community Catalog

Fig. 1 illustrates findings from the first part of the study, which focused on a broad visual analysis of growing communities across California and their relationship to the WUI and past wildfire events. These maps show the historical fire perimeters in orange and the WUI designation in gray. The fire perimeters are overlaid on top of one another, so darker orange indicates an area that has had multiple fires. Two broad-scale findings from the exercise were that, within three miles of their municipal boundaries, 96% of the cities mapped had wildland-urban interface areas, and 84% had historical fire perimeters. Another finding was that communities with the strongest relationship to the WUI and past wildfire events tended to be located in the southern reaches of the state, typically in the exurban areas of Los Angeles and San Diego. These communities included: 1. Irvine, 2. Lake Elsinore, 7. Menifee, 13. San Marcos, 17.Temecula, 23. Chino Hills, 24. Chula Vista, 27. Murietta, 30. Corona, 32. Lake Forest, 41. Santee, 42. Fontana, 45. Hemet, 48. Moreno Valley and 54. Rancho Cucamonga. The only major outlier of this list that was not located in southern California was 38. Chico. Another finding was that the two communities with the highest rate of population growth, 1. Irvine and 2. Lake Elsinore, showed a strong relationship with the WUI and historical fire perimeters.

Figure 1. WUI (gray) and historical fire perimeters (orange) mapping of 55 growing California Communities.

4.2 Community Case Study

Fig. 2 illustrates a zoomed-in view of Vacaville, the community selected for the second part of the study. This map shows the historical fire perimeters in orange and the WUI designation in gray. The fire perimeters are overlaid on top of one another, so darker orange indicates an area that has had multiple fires. This figure illustrates that a significant portion of the community sits within the WUI and that there is a history of fire to the west and southwest of the city. For the urban design studio at the University of California, Davis, this map was used as a starting point. In the studio, students were asked to acknowledge the complex and contested terminology of "urban" and "wild" and explore what it might mean to design in the gray area between the two. One of the early assignments in the studio involved an in-depth mapping of the community to better understand potential development areas and associated vulnerabilities. For example, figure 3 shows a land use mapping of Vacaville that was used to analyze access to transit, jobs, shopping, and services. Additionally, Fig. 4 shows a natural hazard mapping of Vacaville using wildfire perimeters and flood risk as primary drivers. The darker tones show areas with increased risk, and the yellow tones show areas with lower risk. Ultimately, all of this information contributed to selecting two centrally-located infill sites in Vacaville (Fig. 5). These two sites were selected because they had not been challenged by fire in the past and are unlikely to be challenged by fire in the future due to their interior location, away from the wildland periphery. Furthermore, these sites have the potential to sustain denser development, supported urban infrastructure, and nearby city amenities. Once selected, students spent five weeks exploring a new paradigm of growth for the community by proposing a range of mixed-use infill projects for the two sites. Coincidentally, two months after the completion of the studio, parts of Vacaville were impacted by the LNU Lightning Complex wildfire, but this event did not impact the two infill sites selected for the studio.

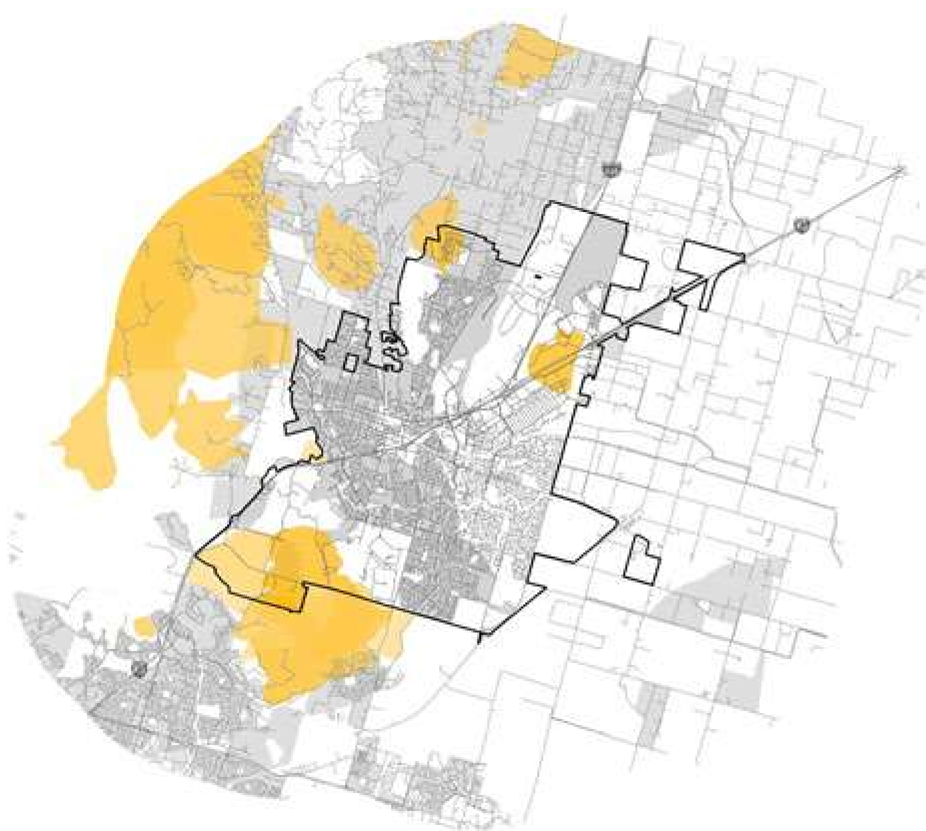

Figure 2. WUI (gray) and historical fire perimeters (orange) mapping of Vacaville.

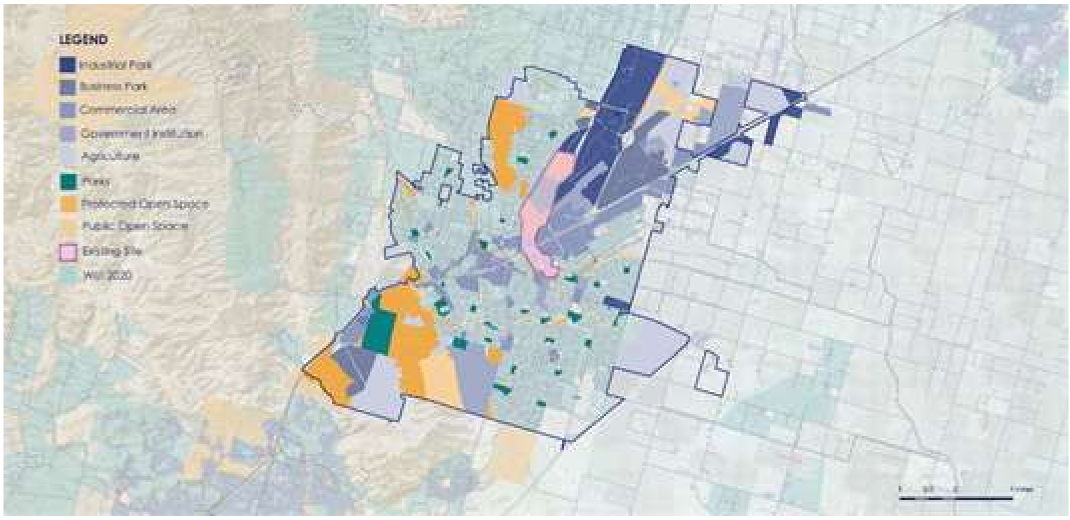

Figure 3. Land use mapping of Vacaville.

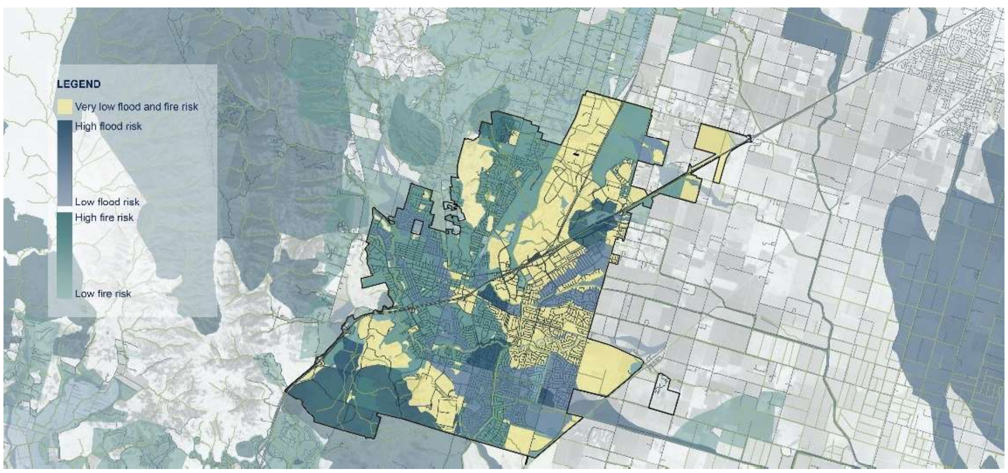

Figure 4. Natural hazard mapping of Vacaville.

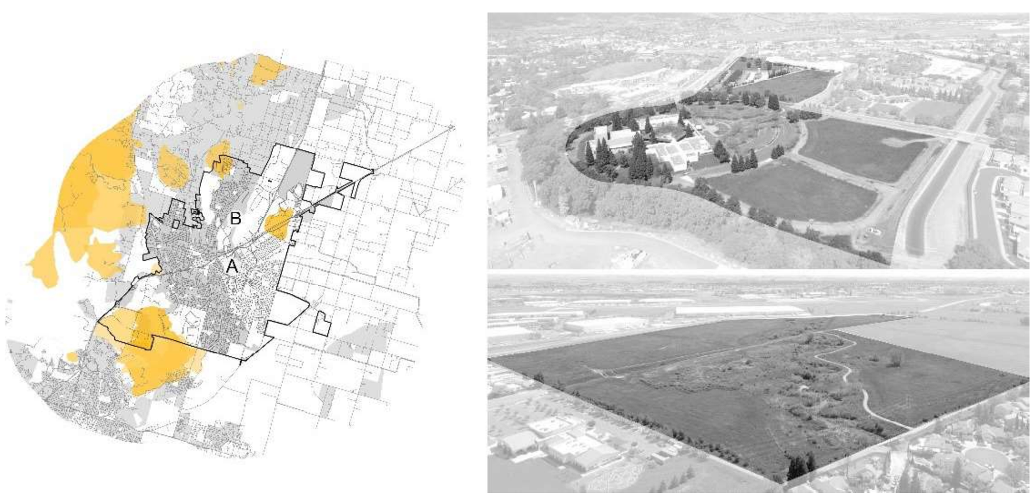

Figure 5. Locations of the two infill sites selected for the urban design studio.

4.3 Limitations

This study has several limitations that could be addressed in future studies moving forward. First, future projects could take into account other data related to wildfire risk, including Fire Hazard Severity Zones (FHSV), Wildfire Hazard Potential (WHP), or spatial fuels and vegetation data from LANDFIRE. Alternatively, future studies could more deeply engage fire ecologists and those focused on mapping and modeling fire behavior. Additionally, future projects could also employ spatial statistics to quantitatively analyze the series of maps produced for the project. Furthermore, a more systematic approach for evaluating potential sites for development in these higher-risk growing communities could be developed, including the use of suitability studies.

5 CONCLUSION

As the threat of wildfire in the WUI increases, it is imperative that landscape architects explore new strategies for bolstering community and ecological resilience. Given that wildfire in the American West is a wicked problem, designers cannot rely on a single strategy or a single scale; rather, they must lean into strategies and scales not typically associated with professional practice.

In California, it is clear that many mid-sized growing cities are situated within or near the WUI and have a history of wildfire events. Thus, this study puts forth a potential development framework for communities that are vulnerable to wildfire by positioning landscape architects as advocates for land use planning strategies that have the potential to bolster resilience. The framework involves geospatial mapping at the city scale to assess potential risks and identify potential infill areas that are less vulnerable to wildfire. These infill areas also promote densification in traditionally sprawling WUI communities.

While the study outlined in this paper is imperfect on many fronts, the hope is that it begins to turn the needle on the increasing threat of wildland fire in the WUI and the potential role of landscape architects in designing for resilience.

6 REFERENCES

Berger, A. & Susskind, J. (2018). Cataloguing the Interface: Wildfire and Urban Development in California, Retrieved January 14, 2021 from: https://lcau.mit.edu/project/cataloguing-interface-wildfire-and-urban-development-california

Bowman, D., Balch, J., Artaxo, P., Bond, W., Carlson, J., Cochrane, M., D'Antonio, C., Defries, R.,

Doyle, J., Harrison, S., Johnston, F., Keeley, J., Krawchuk, M., Kull, C., Marston, B., Moritz, M., Prentice, I., Roos, C., Scott, A., Swetnam, T., Van Der Werf, G., & Pyne, S. (2009). Fire in the Earth System. *Science*, 324, 481-484.

Calkin, D., Gebert, K., Jones, J., & Neilson, R. (2005). Forest Service large fire area burned and suppression expenditure trends. 1970-2002. *Journal of Forestry*, 103(4), 179-183.

Cohen, J. D. (2000). Preventing disasters: Home ignitability in the wildland-urban interface. *Journal of Forestry*, 98, 15-21.

Duke, J. (2016). The Digital & The Wild: Mitigating Wildfire Risk Through Landscape Adaptations, Retrieved September 2, 2021 from: https://www.asla.org/2016studentawards/186884.html

Flohr, Travis. (2019). "Wildfire risk reduction: evaluating local government's implementation of wildfire risk reduction best practices in the American West." Council of Educators in Landscape Architecture Conference, March 6-9, Sacramento, CA, USA.

Flohr, Travis. (2017). "A path to wildfire resilient landscapes: changing the wildfire risk modeling paradigm." Environmental Design Research Association, May 31-June 3, 2017, Madison, WI.

Flohr, Travis. (2016). "Evaluating CWWP effectiveness: wildland fire and defensible space." Council of Educators in Landscape Architecture Conference, March 23-26, 2016, Salt Lake City, UT.

Gilmer, M. (1994). California Wildfire Landscaping. Taylor Publishing Company.

Hulse, D., Branscomb, A., Enright, C., Johnson, B., Evers, C., Bolte, J., & Ager, A. (2016). Anticipating surprise: Using agent-based alternative futures simulation modeling to identify and map surprising fires in the Willamette Valley, Oregon USA. *Landscape and Urban Planning*, 156, 26–43.

Kent, D. (2019). Firescaping: Protecting Your Home with a Fire-Resistant Landscape. Wilderness Press.

Mariposa County. (2020). Agreement for Recreation and Resiliency Planning Services, Retrieved January 14, 2021 from: https://www.mariposacounty.org/DocumentCenter/View/86443/Agreement_2020-058?bidId=

Marlon, J., Bartlein, P., Walsh, M., Harrison, S., Brown, K., Edwards, M., Higuera, P., Power, M., Anderson, R., Briles, C., Brunelle, A., Carcaillet, C., Daniels, M., Hu, F., Lavoie, M., Long, C., Minckley, T., Richard, P., Scott, A., Whitlock, C. (2009). Wildfire responses to abrupt climate change in North America. *PNAS*, 106(8), 2519-2524.

McWethy, D., Schoennagel, T., Higuera, P., Krawchuk, M., Harvey, B., Metcalf, E., Schultz, C., Miller, C., Metcalf, A., Buma, B., Virapongse, A., Kulig, J., Stedman, R., Ratajczak, Z., Nelson, C. & Kolden, C. (2019). Rethinking Resilience to Wildfire. *Nature Sustainability*, 2, 797-804.

Miller, J., Safford, H., Crimmins, M., & Thode, A. (2009). Quantitative Evidence for Increasing Forest Fire Severity in the Sierra Nevada and Southern Cascade Mountains, California and Nevada, USA. *Ecosystems*, 12, 16-32.

Miller, J., Skinner, C., Safford, H., Knapp, E., & Ramirez, C. (2012). Trends and Causes of Severity, Size, and Number of Fires in Northwestern California, USA. *Ecological Applications*, 22(1), 184–203.

Mowery, M. (2021). Land Use Planning: Expanding the Wildfire Risk Reduction Toolkit. Fire Adapted Communities Learning Network, Retrieved September 2, 2021 from: https://fireadaptednetwork.org/land-use-planning-expanding-the-wildfire-risk-reduction-toolkit/

Mullane, R. & Kochanowski, G. (2020). Design for a Changing Climate: Fire and Community Resilience, Retrieved January 14, 2021 from: https://www.hassellstudio.com/conversation/design-for-a-changing-climate-fire-and-community-resilience

Nielsen-Pincus, M., Ribe, R. G., & Johnson, B. R. (2015). Spatially and socially segmenting private landowner motivations, properties, and management: A typology for the wildland urban interface. *Landscape and Urban Planning*, 137, 1–12.

Power, M., Marlon, J., Ortiz, N., Bartlein, P., Harrison, S., Mayle, F., Ballouche, A., Bradshaw, R., Carcaillet, C., Cordova, C., Mooney, S., Moreno, P., Prentice, I., Thonicke, K., Tinner, W., Whitlock, C., Zhang, Y., Zhao, Y., Ali, A., … Zhang, J. (2008). Changes in fire regimes since the Last Glacial Maximum: an assessment based on a global synthesis and analysis of charcoal data. *Climate Dynamics*, 30, 887-907.

Quarles, S., Valachovic, Y., Nakamura, G., Nader, G., & De Lasaux, M. (2010). Home Survival in Wildfire-Prone Areas: Building Materials and Design Considerations, Retrieved January 14, 2021 from: https://escholarship.org/uc/item/4vt8w5qk#author

Radeloff, V., Hammer, R., Steward, S., Fried, J., Holcomb, S. & McKeefry, J. (2005). The Wildland-Urban Interface in the United States. *Ecological Applications*, 15(3), 799-805.

Radeloff, V., Helmers, D., Kramer, H., Mockrin, M., Alexandre, P., Bar-Massada, A., Butsic, V., Hawbaker, T., Martinuzzi, S., Syphard, A. & Stewart, S. (2018). Rapid growth of the US wildland-urban interface raises wildfire risk. *PNAS*, 115(13), 3314-3319.

Radeloff, V., Mockrin, M. & Helmers, D. (2018). Mapping Change in the Wildland Urban Interface (WUI), 1990-2010, State Summary Statistics. Retrieved September 2, 2021 from: http://silvis.forest.wisc.edu/GeoData/WUI_cp12/WUI_change_1990_2010_State_Stats_Report.pdf

Rios. (2020). Sustainable Defensible Space. Retrieved January 14, 2021 from https://www.rios.com/projects/sustainable-defensible-space/

Shannon, K. & Kaufman, D. (2018). California is Burning: Rethinking the Wildland (Sub)urban Interface, Retrieved January 14, 2020 from: http://landezine.com/index.php/2018/01/california-is-burning-rethinking-the-wildland-suburban-interface/

Soles, C. (2014). Fire Smart Home Handbook: Preparing for and Surviving the Threat of Wildfire. Lyons Press.

Steel, Z., Safford, H. & Viers, J. (2015). The fire frequency-severity relationship and the legacy of fire suppression in California forests. *Ecosphere*, 6(1), 1-23.

Stein, S., Comas, S., Menakis, J., Carr, M., Stewart, S., Cleveland, H., Bramwell, L. & Radeloff, V. (2013). Wildfire, Wildlands, and People: Understanding and Preparing for Wildfire in the Wildland-Urban Interface, Retrieved September 9, 2020 from: https://www.fs.fed.us/openspace/fote/reports/GTR-299.pdf

Syphard, A. D., & Keeley, J. E. (2019). Factors Associated with Structure Loss in the 2013–2018 California Wildfires. *Fire*, 2(3), 49.

Toth, S. (2018). Pyro-Diversion: Planning for Fire in the San Gabriel Valley, Retrieved September 2, 2021 from: https://www.asla.org/2018studentawards/494988-Pyro_Diversion.html

ULI. (2020). Developing Resilience: Rancho Mission Viejo, Retrieved January 14, 2021 from: https://developingresilience.uli.org/case/rancho-mission-viejo/

Westerling, A., Hidalgo, H., Cayan, D. & Swetnam, T. (2006). Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity. *Science*, 313, 940-943.

Whitlock, C., Marlon, J., Briles, C., Brunelle, A., Long, C. & Bartlein, P. (2008). Long-term relations among fire, fuel and climate in the northwestern US based on lake-sediment studies. *International Journal of Wildland Fire*, 17, 72-83.