Effect of wildfire on invertebrate communities in riparian chaparral

Laurel Martin

Abstract A recent wildfire at a well-studied site offers the opportunity to explore the ability of a chaparral insect community to recover from a large-scale disturbance. Human settling has influenced fire regimes in this country, with fire suppression often backlashing with large wildfires such as that in Napa County in 1999 or in Yellowstone National Park in 1988. Wildfires can have devastating and long-lasting effects on the physical and biological characters of a riparian environment. As macroinvertebrates are often used as biological monitors in riparian zones, this study monitors the post-fire recovery of a chaparral community in a riparian zone by measuring differences in invertebrate communities between burned and unburned sites. Samples collected using pitfall traps at burned and unburned sites were sorted and identified to the family level. Differences seen between the burned and unburned macroinvertebrate communities reflect the damage caused by intense wildfire as well as the riparian chaparral's ability to recover two and a half years following the catastrophic blaze. Observed differences, however, proved statistically significant in only one case, the proportion of flying insects in the burned and unburned area. Results indicate that recovery on the edge of the burn is sufficient to be unable to prove statistically that the two populations sampled were indeed from two separate populations. Despite the high percentage of non-flying insects in the burned area, this study concludes that there is no statistically significant difference between burned and unburned populations within the study area.

Introduction

Fire is known to be a key process in Mediterranean ecosystems, such as the chaparral and oak woodlands of the Inner Coast Range of California (Harrison 1997). Fires naturally occur infrequently, on the order of decades, and patterns have been greatly altered by humans in recent history. In the last century, with increasing human settlement in the western United States, fire suppression became a common practice. Fire has been reintroduced only recently on a small scale as a management tool (Martin 1990). Because of this disruption in the fire regime, the role of fire in community, population, and ecosystem dynamics is not well understood.

Wildfires are increasing in size and intensity even as humans work harder to suppress them. As a result of fire suppression, a build-up of fuel has accumulated in many areas, resulting in catastrophic wildfires in some instances. While many support prescribed-burning as an effective means to combat this problem (Martin 1990, DellaSala *et al.* 2001), others suggest that the use of wildland fire may be the answer (Ingalsbee 2001). If fire is to be used in either manner to achieve a better balance between humans and ecosystems, it is necessary to understand the effects of fire upon the target ecosystem. While it is known that many large-scale natural disturbances such as wildfire may have long-term implications for ecosystem structure and function (Minshall *et al.* 2001), these effects are not largely understood.

On October 16, 1999, a 40,000-acre wildfire burned portions of Yolo, Lake and Napa Counties in California. This included about 1,000-acres of the McLaughlin UC Natural Reserve, located upon a 7,000-acre property of the Homestake Mining Company, which is becoming a reserve within the University of California Natural Reserve System as the mine is decommissioned. This reserve has been the site of many studies of terrestrial plants and aquatic invertebrates, providing numerous years of data and knowledge of the area (Harrison 1997), however, there has been little work done concerning terrestrial invertebrates.

Invertebrates are often used as indicators of ecosystem health following large-scale disturbances such as wildfires (Minshall *et al*. 2001). Due to the rapid turnover of generations and the ability to fly, insects can recolonize a burned area at a much faster rate than other larger animals, as well as reflect any differences between the burned and unburned portions. Invertebrates also display great taxonomic diversity, ecologically inhabiting a large number of niches (Garcia-Villanueva *et al*. 1998). While many studies have examined the effects of wildfire on aquatic invertebrates (Minshall *et al*. 2001; Minshall *et al*. 1989; Mihuc *et al*. 1995;Gurtz *et al*. 1984), few have examined the effects upon terrestrial invertebrates (Garcia-Villanueva *et al*. 1998). This fire provides a unique opportunity to study the effects of wildfire upon riparian chaparral insect communities and examine any differences between burned and unburned areas.

Two and a half years following the wildfire, I proposed that there would be a significant difference in the invertebrate communities between the burned and unburned areas in three general ways. I hypothesized that flying invertebrates would recolonize the burned area more rapidly than non-flying invertebrates, therefore flying invertebrates would predominate at the burned sites. Unburned sites will also have a larger invertebrate population as well as more diversity within that population. These differences indicate the ability of the burned area to recover following a large-scale disturbance as compared to the adjacent unburned area.

Methods

McLaughlin UC Natural Reserve, in Napa County, California, is comprised of an oak woodland-chaparral ecosystem. This unique chaparral derives from the serpentine soils in the area. The 1999 wildfire burned some of the upper portions of the Knoxville Creek watershed, while leaving the uppermost portion unburned. This section of creek, located in the southern portion of the reserve, was used for this study. The slopes of the banks of the creek are covered in low chaparral vegetation, including oak shrubs characteristic of this ecosystem. Burn scars on trees are clearly visible throughout the hillsides, and it is clear in many places which path the fire followed.

Along the main road through the reserve, about one mile south of the mining headquarters, the oak woodlands change to serpentine chaparral. Sites selected for this study were located approximately one mile south of the mining office (unburned), and 1.5 miles south of the office (burned), along the road. At two randomly selected points, (with the following characteristics: burned or unburned, chaparral vegetation, shallow slope, and within 30m of the creek bed), a 30m transect was laid, following the line of the road and creek (which run parallel through this portion of the reserve). At each 10m interval along the transect, three pitfall traps were randomly placed using a random numbers table within a 1m² quadrat, for a total of 12 traps along the transect (Fig. 1).

Traps consisted of a pitfall trap constructed of a 16 oz. plastic cup, with ten 2cm holes cut through the sides, 5 below ground and 5 level with the soil (Fig. 2).

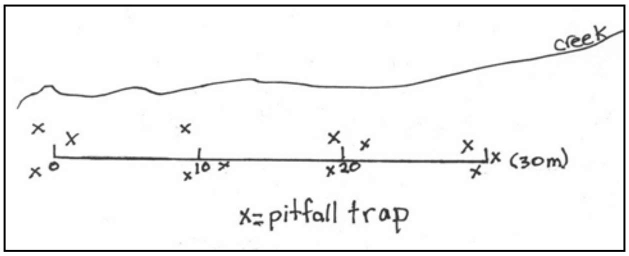

Figure 1. Trap layout.

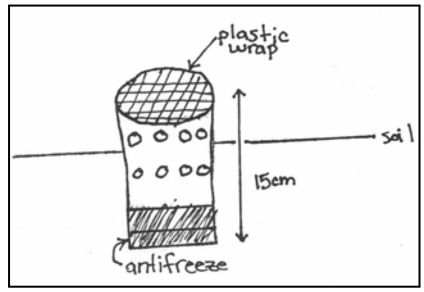

Figure 2. Pitfall trap design.

These traps were filled with approximately 2 oz. of antifreeze to act as a preservative, while the top of the cup was covered with plastic wrap secured with a rubber band to prevent the entry of small rodents, while also leaving holes accessible. These were then buried in the ground so that the top row of holes would be level with the soil. Traps were left in the field for 8 days. Both sites were along similar facing slopes and located approximately 0.5 mile apart along the main road of the reserve.

Two trials were conducted in this manner during late February 2002. Upon collection, samples were returned to the lab, sifted through a fine sieve, and identified to the family level, with the exception of spiders, which were grouped into morphospecies based upon physical characteristics. After dividing these groups into flying and non-flying invertebrates, a chi-square test was performed to determine if the proportion of flying invertebrates was the same in both burned and unburned areas. A Mann-Whitney U test was also performed to test the difference in the level of diversity between the two sites, as well as an independent samples t-test for significance. These data are an indicator of the riparian chaparral invertebrate community's ability to recover from a disturbance such as wildfire.

Results

A total of 47 traps were collected and 308 invertebrates identified from the pitfall traps at McLaughlin Reserve, representing 28 different family groups. Samples were predominately spiders, ants, and several families of flies (Table 1).

	Burned	Unburned
Arcididae grasshopper	0	1
Bombyliidae bee flies	0	1
Culicidae mosquitoes	0	1
scarab beetles	0	1
Scutelleridae bugs	0	1
Curculionidae weevils	0	2
Miridae bugs	0	2
spider G	0	2
spider F	0	4
Curcinophoridae earwig	1	0
Decapod	1	0
Hodotermitidae termites	1	0
spider E	1	0
spider H	1	1
Tingidae bugs	1	1
Diplopoda #1	1	3
Lygaediae bugs	1	6
beetle larvae	2	1
spider D	2	4
Diplopoda #2	3	0
spider C	4	17
Tipulidae crane flies	5	4
Gryllacrididae crickets	6	1
Muscidae flies	8	16
carabid beetles	10	18
Syrphidae flies	12	44
Form. ants	15	8
spider A	23	30
spider B	28	13
totals	126	182

Table 1. Number of individuals collected in burned and unburned areas.

On average, there were more invertebrates collected at the unburned site, as well as more in each trap, than in the comparable burned site. Calculation of the chi-square test resulted in a X^2=16.87, showing a significant difference between the burned and unburned areas in the proportion of flying insects (Table 2).

	Burned	Unburned	total
flying	38	98	136
non-flying	88	84	172
total	126	182	308

Table 2. Total number of flying and non-flying invertebrates collected.

The Mann-Whitney U test for diversity, U=485.5, p=0.159, showed no significant difference between the two populations, indicating that the two samples came from the same invertebrate population. Finally, a t-test (p= 0.055) showed no significant difference in total number between the burned and unburned sites. Overall, the differences shown between the burned and unburned sites were minimal and not significant. Traps from both burned and unburned sites contained predominately carabids, Syrphidae and Muscidae flies, ants, and three different types of spiders (Fig. 3). The traps collected at the burned sites contained, on average, more ants and the spider B than the unburned, or control, sites. In comparison, the control sites contained more carabid beetles and Syrphidae flies.

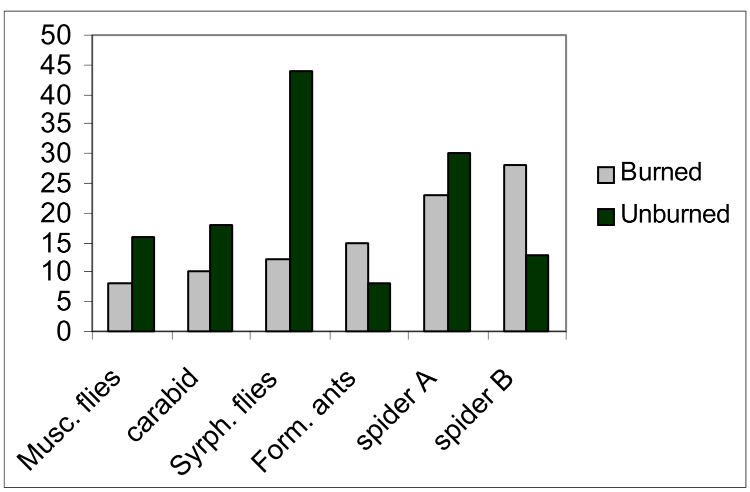

Figure 3. Total number of individuals of the 6 most commonly collected groups.

Discussion

Results indicate that there is no statistically significant difference between the two communities sampled. The only significant difference was found in the proportion of flying insects at each site. While the control or unburned samples were found with approximately equal proportions of flying and non-flying invertebrates (54% flying), burned samples contained less than one third flying invertebrates. This difference, while statistically significant, does not support my hypothesis that the burned area would contain more flying invertebrates due to their ability to recolonize faster. This may be caused by the fact that, as some studies have shown, smaller and wingless insects tend to survive fires better than larger insects, although species diversity is reduced (Garcia-Villanueva *et al.* 1998). Differences may also be due to misidentification; some insects have flying and non-flying members within a family or group. The invertebrates collected at McLaughlin may have been mistakenly identified as flying, yet actually were non-flying forms (i.e. beetles).

The Mann-Whitney U test was unable to statistically support my hypothesis that the unburned areas had greater biodiversity, showing no statistically significant difference between the two communities sampled. The majority of family groups are shared between the burned and unburned areas, and as shown, differences in total numbers are not significant. While there were many differences between the two communities, in terms of total number of different groups, total number of individuals, and evenness (Table 1), these are slight when compared with the similarities between them. The t-test also did not support my hypothesis that there were a significantly larger number of invertebrates in the unburned area. However, the obtained p-value (0.055) shows that it may be possible to achieve significance with a larger sample size.

Variability between the two populations may be due to several factors. Although utmost care was used when choosing sites, the weather cannot always be predicted; and upon the second trial it was noted that the burned sites were located in an area where the soil contained slightly more moisture than in the control sites. This may have affected the differences noted, especially the presence of a solitary decapod. Additionally, in the first trial, one trap was found uprooted and empty, and in the second trial, one trap was found uncovered; these factors may have skewed the results slightly. As noted earlier, smaller and wingless insects may be able to survive fires better than larger insects (Garcia-Villanueva *et al.* 1998), yet this does not explain the large number of spiders that were found at the burned sites (49% of total). Differences between the sites may also be due to the ability of certain spiders to exploit recently burned habitats. This aspect was not explored in depth in this study and should be incorporated in future works.

Overall, results indicate that the riparian chaparral has recovered to support a diverse and rich invertebrate community. Two and a half years following a large-scale disturbance event, no statistically significant difference was found in the invertebrate populations between the burned and unburned areas. This indicates that the 1999 wildfire, while larger and more intense than historical fire regimes of the ecosystem, may not have caused lasting effects to the riparian chaparral communities. This may also indicate the presence of invertebrates that are relatively fire adapted. Previous studies conducted over longer time periods have shown dramatic fluctuations in invertebrate populations in recently burned areas (Minshall *et al.* 2001), indicating that recovering communities may not have reached equilibrium yet. To truly test these hypotheses, it would be necessary to conduct sampling over a longer time period, as well as over a larger area of the burn. In this study, sampling sites were restricted to the area on the edge of the wildfire; thus, populations may have simply recolonized from adjacent unburned habitat. This in no way shows recovery of the total area of the wildfire.

Due to the nature of this project, this is a preliminary study. A more accurate survey of terrestrial invertebrates found on the reserve would provide a basis for comparison for a study of this type. There is still much work to be done in this area on terrestrial invertebrates. If this study were expanded it would be possible to determine the rate of recovery of the riparian chaparral in McLaughlin UC Natural Reserve from a large-scale wildfire.

Acknowledgments

I would like to thank all of those who have contributed to this study. The instructors of Environmental Science 196, John Latto, Matt, Justin and Manish, thank you for your guidance and advice. Thanks also to the staff of McLaughlin UC Natural Reserve, especially Virginia Boucher and Scott Waddell for their support.   I would like to include a special thanks to Katrina Alfon and Joshua Martin for their help and moral support in the field. And most of all I would like to thank Leah Rogers, Vince Resh, and everybody else at the Resh Lab for all of their patience, help, and time.

References

Chambers, BQ and MJ Samways. 1998. Grasshopper response to a 40-year experimental burning and mowing regime, with recommendations for invertebrate conservation management. Biodiversity and Conservation 7:985-1012.

DellaSala, D.A. and E. Frost. 2001. An ecologically based strategy for fire and fuels management in national forest roadless areas. Fire Management Today 61:12-23.

Dombeck, Mike. 2001. A national fire plan for future land health. Fire Management Today 61: 4-8.

Gandhi, K.J K.; Spence, J.R.; Langor, D.W.; Morgantini, L.E. 2001. Fire residuals as habitat reserves for epigaeic beetles (Coleoptera: Carabidae and Staphylinidae). Biological Conservation 102: 131-141.

Garcia-Villanueva, J.A.; Ena, V.; Tarrega, R.; Mediavilla, G. 1998. Recolonization of two burnt *Quercus pyrenaica* ecosystems by Coleoptera. International Journal of Wildland Fire 8: 21-27.

Gurtz, M.E. and J.B. Wallace. 1984. Substrate-mediated response of stream invertebrates to disturbance. Ecology 65: 1556-1569.

Hansen, JD. 1986. Comparison of insects from burned and unburned areas after a range fire. Great Basin Naturalist 46:721-727.

Harrison, S. 1997. How natural habitat patchiness affects the distribution of diversity in California serpentine chaparral. Ecology 78: 1898-1906.

Ingalsbee, Timothy. 2001. Wildland fire use in roadless areas: restoring ecosystems and rewilding landscapes. Fire Management Today 61:29-32.

Joint Fire Science Program. 1999. Proposal: A national study of the consequences of fire and fire surrogate treatments. http:/ffs.psw.fs.fed.us/execsumm-4-17-00.html.

Manley, J.; Keifer, M.B.; Stephenson, N.; Kaage, W. 2001. Restoring fire to wilderness: Sequoia and Kings Canyon National Parks. Fire Management Today 61:24-28.

Martin, R.E. 1990. Goals, methods, and elements of prescribed burning. Pages 55-66 *in* Natural and Prescribed Fire in Pacific Northwest Forests. Walstad, J.D., Radosevich, S.R. and D.V Sandberg, eds. Oregon State University Press, Corvallis, Oregon.

Mihuc, T.B. and G.W. Minshall. 1995. Trophic generalists vs. trophic specialists: implications for food web dynamics in post-fire streams. Ecology 76: 2361-2372.

Minshall, G.W. *et al.* 1989. Wildfires and Yellowstone's stream ecosystems. Bioscience 39: 707-715.

Minshall, G.W.; Robinson, C.T.; Lawrence, D.E.; Andrews, D.A.; Brock, J.T. 2001. Benthic macroinvertebrate assemblages in five central Idaho (USA) streams over a 10-year period following disturbance by wildfire. International Journal of Wildland Fire 10:201-213.

Minshall, G.W.; Royer, T.V.; Robinson, C.T. 2001. Response on the Cache Creek macroinvertebrates during the first 10 years following disturbance by the 1988 Yellowstone wildfires. Canadian Journal of Fisheries and Aquatic Sciences 58: 1077-1088

Snyder, Gary. 2001. Sustainable forestry practices: science can suggest them but the culture must choose the path. Fire Management Today 61:33-36.