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MES Analytical Essay

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Effects of Fire-burned Habitat on Bat Populations

With climate change progressing rapidly, wildfires worldwide are becoming more frequent and impacting regions on a larger scale. The adverse effects of climate change on human and wildlife populations have been a topic of concern for many years. In 1990, the federal government amended the Clean Air Act of 1970 to reduce anthropogenic sources that fueled climate change significantly. The Environmental Protection Agency (EPA) was required to set national emission standards and mitigate significant environmental threats, including acid rain, stratospheric ozone depletion, and toxic air emissions. A national operating permits program was also implemented to increase enforcement and assure compliance with the act (The Clean Air Act, 2023).

Wildfires have increased substantially, particularly on North America's West Coast for over half a century. Studies conducted in California from 1996 to 2021 have shown that wildfires have increased five times compared to studies conducted from 1971 to 1995. A study by the National Integrated Drought Information System (NIDIS) proved this increase results from human-caused climate change. In collaboration with the NIDIS, research at the University of Los Angeles confirmed a rise in surface air vapor pressure deficit (VPD) (Climate Change to Blame, 2023). According to previous studies, an increase in human emissions of greenhouse gases is partly causing this rise in VPD on the West Coast (Climate Change is the Main Driver, 2021). While climate change is considered a significant threat to most wildlife populations, evidence suggests that, on a long-term basis, an increase in fire-burned habitat may benefit many bat populations.

A study by the University of California, Davis, revealed that the effects of high-severity wildfires over four years positively impacted Sierra Nevada bat populations. Burn severity and pyrodiversity effects were tested using acoustic surveys on 17 bat species. Each individual species responded differently, but the species richness increased from 8 species in unburned forests to 11 species in forests that experienced high-severity burns. To confirm which species were present, the ultrasonic audio data were converted into a spectrogram, assisting in identifying bat species. Species occurrence rates were then compared to habitat conditions. While multiple bat species utilize densely forested areas and open meadows and valleys, researchers believe that decades of fire suppression have led to unusually dense forests. Forest bats have evolved to use dense forests as roosting grounds, but there is a need for open habitats that allow for easier access to insects, which are their primary food source. Forests with high-severity burns increase the amount of open area, which increases the ease of foraging for food. Burned snags and dead trees may also provide ideal roosting sites for some bat species. (Kerlin, 2021).

High-severity burns can also damage bat populations on a short-term basis. Sudden and drastic habitat loss from high-severity wildfires may force bats out of their breeding and roosting grounds. While bat species across the globe mate and give birth at different times of year depending on location and weather conditions, most do so in spring through later summer. Mature females only give birth to one or two pups a year, and high-severity burns during this period could harm threatened or endangered species whose population numbers are already dwindling. Laboratory experiments on United States and Australian bat species confirmed that bats also experience significant death rates from high intensity fast, fast-moving wildfires. Depending on the time of day when a wildfire ignites, bats are typically in torpor in the early morning, which means a delayed response time to early signs of an approaching fire. A study in Southern Italy revealed that closed-spaced foraging bat species mainly show negative responses to wildfires, with a considerable decline in detections one-year post-wildfire. (Loeb & Blakey, 2021). These species prefer dense forests and roost farther away from burn sites. High-severity burns can reduce suitable conditions for insect reproduction, increasing foraging costs for bats (Snider et al., 2013). Homogenous habitats are often a result of high-intensity wildfires, which also limit the amount of bat species diversity in forests that were once high in forest-edge and closed-space foraging bat populations (Steel, Z. L. et al., 2019). A study conducted in Arizona also suggests that burn severity is not the most essential factor when monitoring negative post-fire impacts on bat populations. Researchers found that water sources and elevation range were more important when evaluating the immediate effects of wildfires (Starbuck et al., 2020)

The introduction of a fungal infection responsible for white-nose syndrome (WNS) in North American bat populations has also been a topic of concern. Ideal conditions for the fungus *Pseudogymnoascus destructans* include high amounts of moisture and cooler temperatures. Studies have suggested that the warming and drying effects of climate change could be beneficial in curbing WNS infections in bats. A study involving prescribed burns at Mammoth Cave National Park in Kentucky revealed an increase in the detection rate of foraging bats, including *Myotis* populations, where researchers previously found white-nose syndrome. Unburned habitats in the park were used more by *Myotis* bat species before WNS was first detected due to their clutter tolerance. However, after WNS was detected, a decrease in *Myotis* detections occurred. This was thought to be a result of the negative impacts of WNS on bats' physical condition with damage to wings, which can cause more energy exertion while foraging through dense forests with more canopy to maneuver around (Cryan et al. 2010; Lacki et al. 2015; Griffitts, 2016). Multiple studies agree that burned areas had more bat activity than unburned sites, specifically when looking at post-WNS detection on open-space foragers due to decreased canopy clutter. In the same study, insect abundance before and after WNS and in burned sites was recorded. Results found that after the arrival of WNS, insect populations increased compared to insect abundance beforehand. This also indicates an increase in insects in burned areas, which is highly beneficial for open-space foraging bat species (Griffitts, 2016). A study conducted in mixed pine-oak forests in the Cumberland Plateau of South Carolina concluded that ideal burn aftermaths would include variegation of unburned patches mixed with areas of high and low-intensity burns to facilitate open-foraging and clutter-tolerant bat species as well as support other organisms that exist in a symbiotic relationship with bats (Leanne et al., 2019).

Bats are not the only organisms to benefit from wildfires and prescribed burns in fire-suppressed forests. A study in Azark National Forest in Arkansas examined the relationship between insects and forest management practices. Varying burn frequencies and mechanical thinning were conducted in thirty treatment stands over twelve years. Light traps were deployed in each stand every month from March to November 2019 to evaluate for nocturnal bat prey. Stands with high-frequency burns and no mechanical thinning yielded more diversity in moth and butterfly (*Lepidoperta)* species and biomass and abundance in beetles (*Coleoptera)*. Researchers agree with a high probability that bats spend less energy when they do not have to avoid clutter while foraging; hence, a reason for fewer nocturnal flying insects in the thinned stands (Tormanen et al., 2021). Thinning removes trees that insects would typically utilize as sources of food and shelter from predation. Burning, on the other hand, changes the composition of the trees, but *Lepidopterans* and *Coleopterans* can still utilize the remaining snags as sources of food and shelter.

The effects of fire-burned habitat on bat populations are highly variable. Multiple factors should be considered when planning forest management practices and evaluating climate change influences on bat populations, including timing, location, the severity and type of burn, the roosting and foraging techniques of individual bat species, and the water accessibility and elevation of burn sites. On a short-term basis, high-severity burns have a negative effect on most bat populations due to sudden and drastic changes in the environment where food and shelter are significantly reduced. However, studies suggest that the long-term effects of high-severity burns positively effect bat populations and other organisms that coexist in a symbiotic relationship. The consensus of multiple researchers leans toward an agreement on more positive effects of burning overall, especially when considering years of fire suppression due to Western anthropogenic influence.

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