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Prescribed fire and natural recovery produce similar long-term patterns of change in forest structure in the Lake Tahoe basin, California

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ABSTRACT

In the context of concerns about degrading forest health, increasing fire activity, and practical restoration alternatives, we analyzed 20 years of data on the response of mixed conifer forest stands in the Sierra Nevada, California to two distinctly different management approaches. Specifically, we used a Bayesian hierarchical modeling approach to evaluate the direction and magnitude of changes in forest structure and fuel variables in areas treated with prescribed fire as well as untreated forest stands in the Lake Tahoe basin. Counter to many regional studies, our results indicated that treated and long-unaltered, untreated areas may be moving in a similar direction. Treated and untreated areas experienced declines in tree density, increases in the size of the average individual, and losses of surface fuels in most size classes. The number of large trees increased in untreated areas, but decreased in treated areas. Our results suggested that untreated areas may be naturally recovering from the large disturbances associated with resource extraction and development in the late 1800s, and that natural recovery processes, including self thinning, are taking hold. Given the high cost and broad extent of treatment required to restore forest health, management approaches that promote naturally recovering landscapes may complement ongoing and planned fuel reduction treatments. Deliberately managing for natural processes to proceed unimpeded may also be important for maintaining or increasing forest heterogeneity, resilience, and biodiversity.

1. Introduction

Increasing wildfire frequency, size, and associated economic costs under a warming climate are growing concerns for resource managers and the public alike (Schoennagel et al., 2017). In the Sierra Nevada of California, past land disturbance and a century of fire suppression have been implicated as the principal drivers of present-day forest conditions (Dolanc et al., 2014; Knapp et al., 2013; Stephens and Ruth, 2005; Stevens et al., 2016). These factors may compound the climate-driven increase in susceptibility of mixed conifer forests in the region to disease- and drought-caused mortality (Asner et al., 2016) and fire severity (Parks et al., 2014). Accordingly, urgent action to increase the pace and scale of fuels treatment has been recommended to restore forest health and resilience, and to mitigate the risk of undesirable wildfire events over extensive areas (North et al., 2012; SNC, 2017).

Management actions that move forests towards pre-settlement structural conditions are expected to increase fire resilience, and restoration to reduce tree density is the management recommendation for large portions of the Lake Tahoe basin (Taylor et al., 2014). This view is not limited to the Lake Tahoe basin as millions of hectares of forest in the western United States may need restoration to increase resilience to fire, insects, and drought (Stephens et al., 2016). The recommended restoration methods involve fuel treatments that reduce tree density and surface fuel loads using mechanical tree removal and/or fire management (Brown et al., 2004; Agee and Skinner, 2005), and studies link these structural treatments to different measures of increased ecological resilience (Hood et al., 2016; Stevens et al., 2014; Reinhardt et al., 2008; Loudermilk et al., 2017). Although forest restoration and fuel treatments that focus on the retention of large trees and removal of small trees (i.e., 'ladder' fuels) and surface fuels can be effective in reducing overall tree mortality and fire severity in this region (Brown et al., 2004; Safford et al., 2012), treatment effectiveness decays over time and routine re-treatment is often necessary (Kalies and Yocom Kent, 2016; Reinhardt et al., 2008; Stephens et al., 2012; Vaillant et al., 2013). The combination of transient treatment effects, variability in the effectiveness of different treatment methods (Kalies and Yocom Kent,

Abbreviations: CWD, coarse woody debris; BCI, Bayesian credible interval; MCMC, Markov chain Monte Carlo

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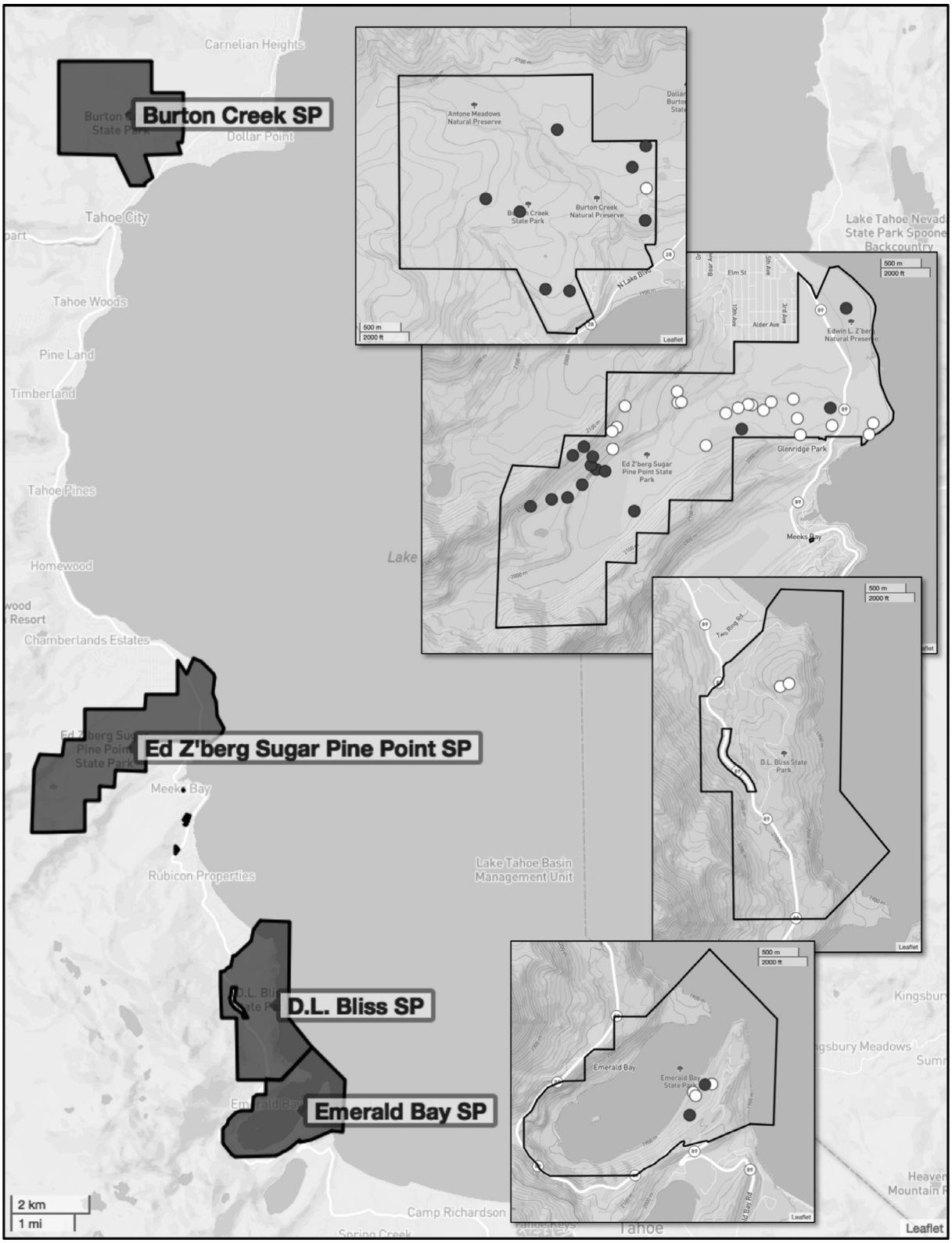

Fig. 1. Study area. The study area includes four state parks on the west shore of Lake Tahoe: Burton Creek, Ed Z'berg Sugar Pine Point, D. L. Bliss, and Emerald Bay state parks. Untreated (control) and treated (burned) plots are shown in dark gray and white circles, respectively.

2016; Martinson and Omi, 2013; Prichard et al., 2010), and operational and funding constraints (North et al., 2015) limits the practicality of frequent treatments at the landscape scale; and there is growing recognition that fuels reduction alone may not be able to effectively alter regional wildfire trends (Schoennagel et al., 2017).

Prescribed natural regeneration (Clewell and McDonald, 2009) is often ignored as a viable land-use option (Chazdon and Uriarte, 2016), but deliberately allowing natural processes to proceed unimpeded in some areas is one method employed as part of California State Parks' overall forest restoration management strategy that includes prescribed