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Key Points:
- Area burned at high severity increased from 1985 to 2017 across most western US forests coincident with warmer and drier fire seasons
- Warmer and drier fire seasons correspond to elevated fire severity and proportion burned at high severity across many western US forests
- Continued climate change could result in more high-severity fire where fuels remain abundant

Supporting Information:
- Supporting Information S1

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Warmer and Drier Fire Seasons Contribute to Increases in Area Burned at High Severity in Western US Forests From 1985 to 2017

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Abstract Increases in burned area across the western United States (US) since the mid-1980s have been widely documented and linked partially to climate factors, yet evaluations of trends in *fire severity* are lacking. Here we evaluate fire severity trends and their interannual relationships to climate for western US forests from 1985 to 2017. Significant increases in annual area burned at high severity (AAB_{hs}) were observed across most ecoregions, with an overall eightfold increase in AAB_{hs} across western US forests. The relationships we identified between the annual fire severity metrics and climate, as well as the observed and projected trend toward warmer and drier fire seasons, suggest that climate change will contribute to increased fire severity in future decades where fuels remain abundant. The growing prevalence of high-severity fire in western US forests has important implications to forest ecosystems, including an increased probability of fire-catalyzed conversions from forest to alternative vegetation types.

Plain Language Summary The physical and ecological effects of wildfire (hereafter fire severity) have important consequences in terms of soil erosion, carbon storage, forest succession, wildlife habitat, and human safety and infrastructure. This study evaluated changes in fire severity in western US forests from 1985 to 2017 and tested whether fire severity varied with fire-season climate. Results show that area burned at high severity increased across most of the study area, with an overall eightfold increase in western US forests from 1985 to 2017. Furthermore, warmer and drier fire seasons corresponded with higher severity fire, indicating that continued climate change may result in increased fire severity in future decades. One potential consequence of greater area burned at high severity is an increased probability that forests will convert to alternative vegetation types. Our findings provide some guidance to managers as society struggles to better coexist with fire. For example, it may be possible to increase the prevalence of low- and moderate-severity fire, sometimes referred to as “good fire”, through thoughtful planning about where and when to implement a less aggressive fire suppression response. Similar to prescribed fires that promote forest resilience, unplanned fires that burn during less-than-extreme fire seasons have the potential to serve as effective “fuel treatments”.

1. Introduction

Several recent studies have found that annual area burned (AAB) by wildfire has increased since the mid-1980s across the western US coincident with warmer and drier conditions (Abatzoglou & Williams, 2016; Dennison et al., 2014; Holden et al., 2018; Westerling, 2016). These studies, however, have not addressed how changes have been borne out through the ecological effects of fire (hereafter fire severity). Indeed, absent from the literature are parallel evaluations of trends in *fire severity* (including its relationship to climate variation) across the vast, fire-prone forest landscapes of western US. Yet the severity at which fire burns is arguably just as important—or more important—as area burned. Stand-replacing or high-severity fire is more likely than low-severity fire to negatively impact systems by, for example, increasing erosion potential (Moody et al., 2013), catalyzing conversions from forest to nonforest (Tepley et al., 2017; Walker et al., 2018), promoting reduced carbon stocks (Hurteau & Brooks, 2011; Liang et al., 2018), and jeopardizing human safety and infrastructure (Calkin et al., 2014; Safford et al., 2009). Conversely, low-severity fire can be beneficial because the resulting reduction in fuel loads and tree density increases the capacity of forests to withstand future drought, insect outbreaks, and fire (Hessburg et al., 2015).

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Several studies have conducted temporal assessments of fire severity at local-to-ecoregional spatial extents (Miller, Knapp, et al., 2009; Miller & Safford, 2012; Miller, Skinner, et al., 2012; Mueller et al., 2020; Reilly et al., 2017; Singleton et al., 2019; Stevens et al., 2017), and to a lesser degree, have spanned large portions of the western US (Abatzoglou et al., 2017; Dillon et al., 2011; Keyser & Westerling, 2017; Picotte et al., 2016). These studies have typically examined either temporal trends in fire severity (e.g., Singleton et al., 2019) or climate's influence on annual fire severity (e.g., Abatzoglou et al., 2017) but not both (except for regional studies conducted by Mueller et al., 2020 & Reilly et al., 2017). Moreover, these studies provide conflicting evidence on recent changes in fire severity. Whereas some studies show increased fire severity over time (Reilly et al., 2017; Singleton et al., 2019), others do not (Keyser & Westerling, 2017; Miller, Skinner, et al., 2012), and still others show mixed results among ecoregions or forest types (Dillon et al., 2011; Miller, Skinner, et al., 2012; Picotte et al., 2016). Given observed and projected changes in climate, a comprehensive evaluation of annual variability and trends in fire severity, and its relationship to climate variation, across the fire-prone regions of western US is necessary to complement parallel assessments of area burned (e.g., Dennison et al., 2014; Westerling, 2016).

The availability of satellite-derived fire severity datasets has vastly improved in recent years thanks to national programs such as the Monitoring Trends in Burn Severity (MTBS) program (Eidenshink et al., 2007) and cloud-based image repositories and computing platforms (i.e., Google Earth Engine) (Gorelick et al., 2017) that allow for the rapid processing of fire severity data sets (Parks, Holsinger, Voss, et al., 2018). In this study, we provide a comprehensive assessment of trends in AAB at high severity (AAB_{hs}), annual mean fire severity (SEV_{mean}), and annual proportion burned at high severity (HS_{prop}) for forested areas in four large fire-prone ecoregions in the western US from 1985 to 2017. We also evaluate AAB to complement the fire severity analyses and to provide an update of previous studies (e.g., Dennison et al., 2014; Westerling, 2016). We also assess the interannual relationships between these fire metrics and climate in each ecoregion. Lastly, we evaluate temporal changes in climatic factors that relate to fire severity.

2. Materials and Methods

We evaluated trends in AAB_{hs}, SEV_{mean}, HS_{prop}, and AAB for each of four large ecoregions in the western US (Figure 1) and conducted parallel evaluations combining the data from all ecoregions to evaluate western US forests as a whole. Ecoregions were based on Olson and Dinerstein (2002) and broadly intended to mimic previous broad-scale evaluations of the area burned in the western US (Dennison et al., 2014; Dillon et al., 2011; Holden et al., 2018). Following Parks, Holsinger, Panunto, et al. (2018), ecoregions with low forest area burned were not evaluated (e.g., hot deserts and temperate rainforests) and nonforest land was excluded from all analyses.

A geospatial data set representing individual fire perimeters spanning 1985–2017 was obtained from the MTBS program (Eidenshink et al., 2007; http://www.mtbs.gov), which generally maps only large fires (>400 ha). Prescribed fires were excluded from the analysis. Using these fire perimeters, we produced raster data sets (resolution = 30 m) representing the *predicted* composite burn index (CBI) using Google Earth Engine (Gorelick et al., 2017) and the model developed by Parks, Holsinger, et al., (2019). The CBI is a composite field measure of fire severity that rates >20 individual factors such as duff consumption, char height, and canopy mortality; as such, modeled CBI allows for improved ecological interpretations of fire effects compared to nonstandardized indices such as the delta normalized burn ratio (dNBR) (Key & Benson, 2006). This procedure maps the predicted CBI using a Random Forest model developed using field data from >250 fires across North America; explanatory variables in this model include Landsat spectral indices, latitude, and 1981–2010 annual average climatic water deficit (CWD). We used the bias-corrected CBI described in detail by Parks, Holsinger, et al. (2019). Cross-validated regressions between modeled (bias-corrected) and observed CBI across the 10 western states covered in this study indicate that this model performs well; mean $R^2 = 0.73$ and ranges from $R^2 = 0.64$ (Washington) to $R^2 = 0.83$ (Arizona). These spatial differences in model performance are not expected to substantially influence this study, particularly because there is no apparent spatial bias in CBI model predictions across the spatial domain of this study. Note that modeled CBI is an improvement over nonstandardized metrics (such as dNBR and derivatives) in terms of its correspondence to field data (R^2), the root mean square error (RMSE), and mean absolute error (MAE) (Parks, Holsinger, et al., 2019), and consequently, uncertainty is reduced using modeled CBI vs. dNBR and similar metrics.

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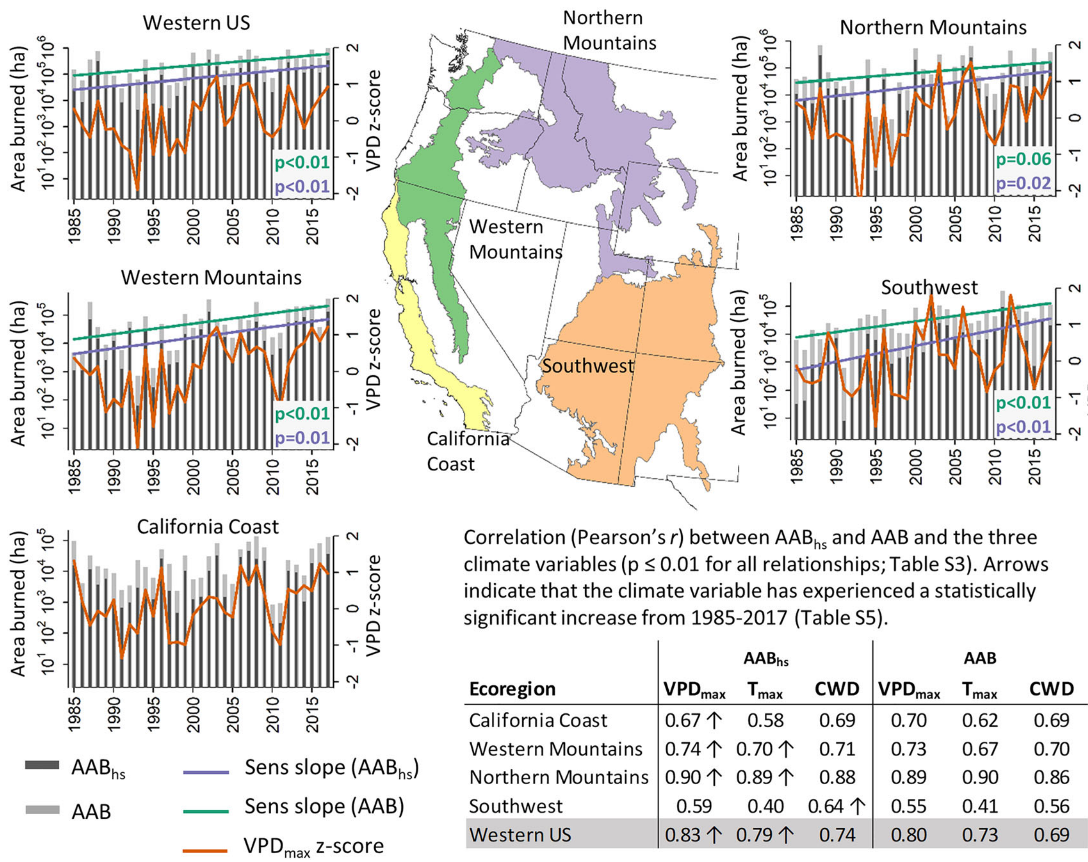


Correlation (Pearson's *r*) between AAB_{hs} and AAB and the three climate variables (p ≤ 0.01 for all relationships; Table S3). Arrows indicate that the climate variable has experienced a statistically significant increase from 1985-2017 (Table S5).

	AAB_{hs}			AAB		
Ecoregion	**VPD_{max}**	**T_{max}**	**CWD**	**VPD_{max}**	**T_{max}**	**CWD**
California Coast	0.67 ↑	0.58	0.69	0.70	0.62	0.69
Western Mountains	0.74 ↑	0.70 ↑	0.71	0.73	0.67	0.70
Northern Mountains	0.90 ↑	0.89 ↑	0.88	0.89	0.90	0.86
Southwest	0.59	0.40	0.64 ↑	0.55	0.41	0.56
Western US	0.83 ↑	0.79 ↑	0.74	0.80	0.73	0.69

Figure 1. AAB_{hs}, AAB, and VPD_{max} from 1985 to 2017. Trends (Theil-Sen's slopes) are shown if they are statistically significant ($p \leq 0.10$). Imbedded table shows correlations between AAB_{hs} and AAB and the three climate metrics. AAB: annual area burned; AAB_{hs}: annual area burned at high severity; CWD: climatic water deficit; T_{max}: mean maximum temperature; VPD_{max}: mean maximum vapor pressure deficit.

We identified forest, woodland, and savanna (hereafter forest) from a combination of landscape level vegetation products that include Landfire's (Rollins, 2009) Existing Vegetation Cover (EVC), Environmental Site Potential (ESP), and the Landsat Time Series Stacks-Vegetation Change Tracker (LTSS-VCT) (Huang et al., 2010). Although this forest mask (Figure S1) has been used in previous studies (Dillon et al., 2020; Parks, Holsinger, Panunto, et al., 2018), we further refined it by excluding all pixels with a prefire normalized differenced vegetation index (NDVI) < 0.35, thereby eliminating low productivity sites that might be misclassified as forest. Prefire NDVI represents the mean NDVI from 1 year before the fire using the same composite imagery used to produce the CBI predictions (Parks, Holsinger, et al., 2019). AAB_{hs} was calculated by tabulating only those forested pixels where CBI ≥ 2.25 for each year; this CBI threshold corresponds to ≥95% canopy mortality (Miller, Skinner, et al., 2009). AAB was tabulated through coalescing forested pixels within each fire perimeter for each year. SEV_{mean} was calculated annually within each ecoregion (as opposed to summarizing by individual fire) as the mean CBI for forested pixels. HS_{prop} was calculated as the AAB_{hs} divided by AAB. We tested for trends in AAB_{hs}, SEV_{mean}, HS_{prop}, and AAB from 1985 to 2017 with the Theil-Sen slope estimator using combination of the “zyp” and “trend” packages in the R statistical platform (R Core Team, 2016). Both AAB_{hs} and AAB were log-transformed; because years with zero area burned cannot be log-transformed, we added 1 ha to all years prior to transforming for all analyses. The Theil-Sen models were used to calculate mean annual increases in AAB_{hs} and AAB. Following Dennison et al. (2014) and Holden et al. (2018), Theil-Sen slopes were considered statistically significant when $p \leq 0.10$; we provide *p* values for all statistical tests for readers interested in applying their own threshold for significance.

We also evaluated the relationship between SEV_{mean}, HS_{prop}, log-transformed AAB_{hs}, and log-transformed AAB with three climate variables that have been shown to correlate well with various measures of fire

Table 1
Predicted (i.e., Modeled) Area Burned at High Severity (AB_{hs}) and Area Burned (AB) in 1985 and 2017 According to the Theil-Sen Fits

Ecoregion	AB_{hs} (ha; 1985)	AB_{hs} (ha; 2017)	AB (ha; 1985)	AB (ha; 2017)
California Coast	—	—	—	—
Western Mountains	4,225	70,568	13,933	210,491
Northern Mountains	6,392	75,693	29,113	164,241
Southwest	531	36,017	7,675	128,301
All	25,903	210,282	88,798	586,272

Note. The California Coast ecoregion did not exhibit a statistically significant positive trend (Figure 1).

activity (Abatzoglou et al., 2017; Williams et al., 2015): mean maximum vapor pressure deficit (VPD_{max}), mean maximum temperature (T_{max}) and CWD. Monthly climate at 1/24th degree resolution from 1985 to 2017 representing VPD_{max} and T_{max} was obtained from PRISM Climate Group, Oregon State University (version AN81m-M3, http://prism.oregonstate.edu, accessed 26 June 2020). These datasets have been recently updated to remedy the artificial elevation-dependent warming described by Oyler et al. (2015). CWD at 1/120th degree resolution was calculated following Dobrowski et al. (2013) using PRISM inputs for temperature, precipitation, and humidity (version LT81m), 10-m wind and downward shortwave radiation from NLDAS2 (Mitchell et al., 2004), and soil water holding capacity from POLARIS (Chaney et al., 2016). VPD_{max}, T_{max}, and CWD were summarized over the lead up to the fire season for each year. Specifically, we summarized the monthly climate data across the entire ecoregion over the 3-month period ending with the month identified as having the most area burned for each ecoregion as defined by the number or monthly Moderate Resolution Imaging Spectrometer (MODIS) active fire detections (NASA MCD14ML product) that intersected fire perimeters and forest during 2001–2017. We explored other temporal windows but found the selected temporal window worked better than other definitions and was similar to those used in previous studies (Abatzoglou & Kolden, 2013). All climate variables were standardized (i.e., converted to z-scores) based on 30-years of climate data (1986–2015); this standardization facilitates intuitive comparisons among ecoregions and climate variables. Climate summaries from June to August were used when evaluating data from all ecoregions as a whole.

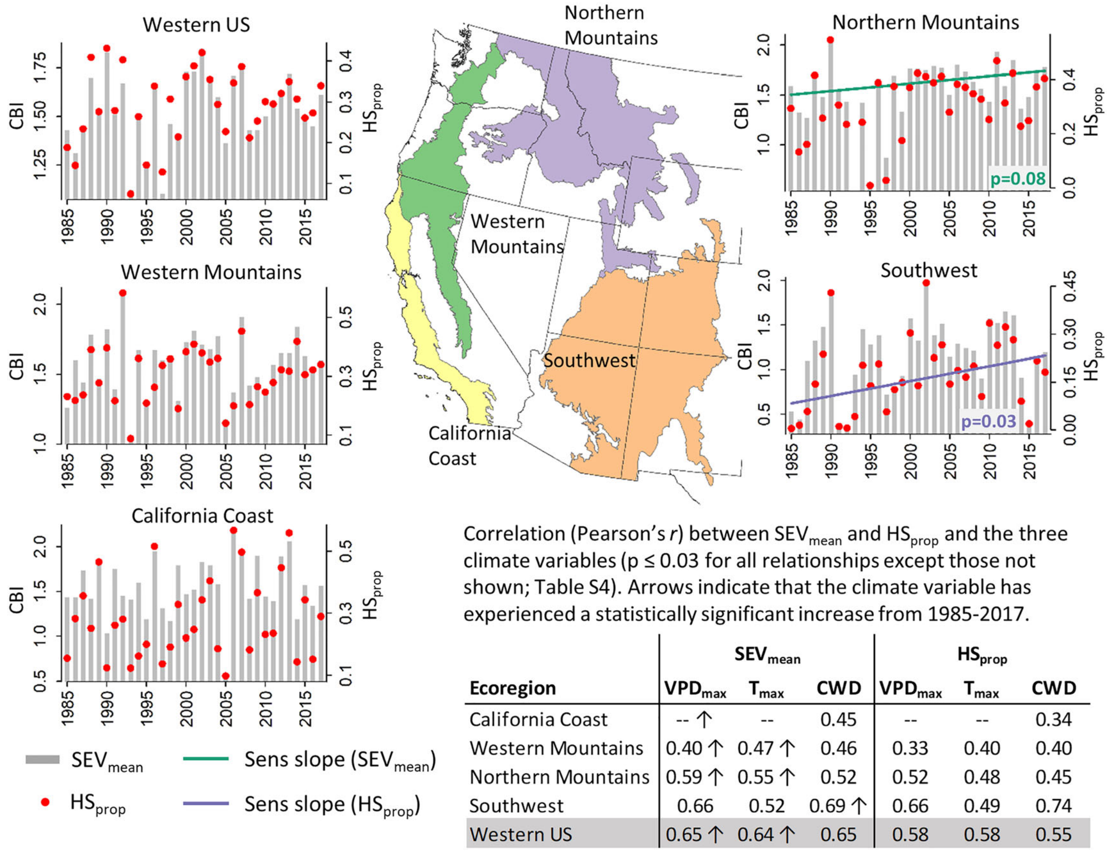
We tested for associations (Pearson's r; one-tailed) between the fire metrics and each climate variable. For relationships with strong statistical inference ($p \leq 0.05$), we also produced linear regression models between fire metrics and climate to provide a measure of the sensitivity of a given fire metric per z-score unit change in fire-season climate. This is straight forward with SEV_{mean} and HS_{prop} models because the relationships are linear. To accommodate the log-linear models for AAB_{hs} and AAB, we quantified change from a baseline representing mean fire-season climate (z-score = 0) to that of one standard deviation towards warmer and drier conditions (z-score = 1). To facilitate comparisons among ecoregions, we characterize the sensitivity of AAB_{hs} and AAB as a percent of forested land within each ecoregion.

Lastly, we quantified trends in VPD_{max}, T_{max}, and CWD from 1985 to 2017 (the time period spanning the fire data) with the Theil-Sen slope estimator using combination of the “zyp” and “trend” packages in the R statistical platform (R Core Team, 2016). Again, Theil-Sen slopes were considered statistically significant when $p \leq 0.10$.

3. Results

All ecoregions except for the California Coast exhibited a statistically significant positive trend in AAB_{hs} and AAB from 1985 to 2017 (Figure 1); significantly positive trends in AAB_{hs} and AAB were also evident across western US forests as a whole. From 1985 to 2017, AAB_{hs} increased by 184,000 ha in western US forests according to the Theil-Sen models; this represents an eightfold increase (Table 1). Similarly, AAB_{hs} for each ecoregion (excluding the California Coast) increased by at least 35,000 ha from 1985 to 2017 according to the Theil-Sen models (Table 1). In terms of SEV_{mean} and HS_{prop}, only the Northern Mountains ecoregions showed a positive trend in SEV_{mean} ($p = 0.08$), and the southwest ecoregion showed a positive trend in HS_{prop} ($p = 0.03$) (Figure 2; Table S2).

Both AAB_{hs} and AAB exhibited positive correlations with VPD_{max}, T_{max}, and CWD in all ecoregions and the western US as a whole (Figure 1). Among ecoregions, for example, AAB_{hs} vs. VPD_{max} correlations (Pearson's r) ranged from 0.59 to 0.90 ($r = 0.83$ for the western US) and AAB vs. VPD_{max} correlations ranged from 0.55 to 0.89 ($r = 0.80$ for the western US) (Figure 1; Table S3). Overall, SEV_{mean} and HS_{prop} exhibited weaker correlations to climate (compared to AAB_{hs} and AAB) (Figure 2; Table S4). For example, correlations (Pearson's r) between SEV_{mean} and VPD_{max} ranged from not significant to 0.66 ($r = 0.65$ for



	SEV_{mean}			HS_{prop}		
Ecoregion	VPD_{max}	T_{max}	CWD	VPD_{max}	T_{max}	CWD
California Coast	-- ↑	--	0.45	--	--	0.34
Western Mountains	0.40 ↑	0.47 ↑	0.46	0.33	0.40	0.40
Northern Mountains	0.59 ↑	0.55 ↑	0.52	0.52	0.48	0.45
Southwest	0.66	0.52	0.69 ↑	0.66	0.49	0.74
Western US	0.65 ↑	0.64 ↑	0.65	0.58	0.58	0.55

Figure 2. SEV_{mean} and HS_{prop} from 1985 to 2017. Trends (Theil-Sen's slopes) are shown if they are statistically significant. Imbedded table shows correlations between SEV_{mean} and HS_{prop} and the three climate metrics. Years with zero area burned are not included in the SEV_{mean} and HS_{prop} correlations or in evaluating trends. CWD: climatic water deficit; HS_{prop}: proportion of area burned at high severity; SEV_{mean}: annual mean fire severity; T_{max}: mean maximum temperature; VPD_{max}: mean maximum vapor pressure deficit.

the western US); HS_{prop} and VPD_{max} correlations ranged from not significant to 0.66 (r = 0.58 for the western US) (Figure 2, Table S4).

Substantial sensitivity in AAB_{hs} and AAB was evident across all ecoregions and western US forests to fire-season VPD_{max} (Figures 3 and S2, Table S3). For example, modeled AAB_{hs} and AAB across all ecoregions increased by 197,000 and 476,000 ha, respectively, as the z-score for VPD_{max} increased from 0 to 1 (Figure S2). Similarly, increases in SEV_{mean} among ecoregions ranged from 0.11 to 0.31 per VPD_{max} z-score and increases in HS_{prop} ranged from 0.04 to 0.08 (excluding the California Coast) (Figures 3 and S2, Table S4). Sensitivity of the fire metrics to other climate variables (T_{max} and CWD) was similar (Figure S2, Tables S3 and S4).

Lastly, trends from 1985 to 2017 towards a warmer and drier climate, as measured by increased VPD_{max}, were exhibited in the California Coast, Western Mountains, and Northern Mountains ecoregions and the western US as a whole (Figure 1). Positive trends in T_{max} and CWD were also evident in some ecoregions (Figure 1; Table S5).

4. Discussion and Conclusions

We demonstrate increases in AAB_{hs} and AAB from 1985 to 2017 across most ecoregions and western US forests as whole. Furthermore, the three fire severity metrics (AAB_{hs}, SEV_{mean}, and HS_{prop}) and AAB exhibited significant correlations with annual fire-season climate in the majority of ecoregions and across western US forests, in that warmer and drier fire seasons corresponded to more fire, more high severity fire, and higher severity fire in general as measured by SEV_{mean} and HS_{prop}. As most ecoregions and the western US exhibited a trend towards warmer and drier fire seasons, our results strongly suggest that (1) observed climate change has contributed to increased AAB_{hs} and AAB and (2) continued climate change as viewed

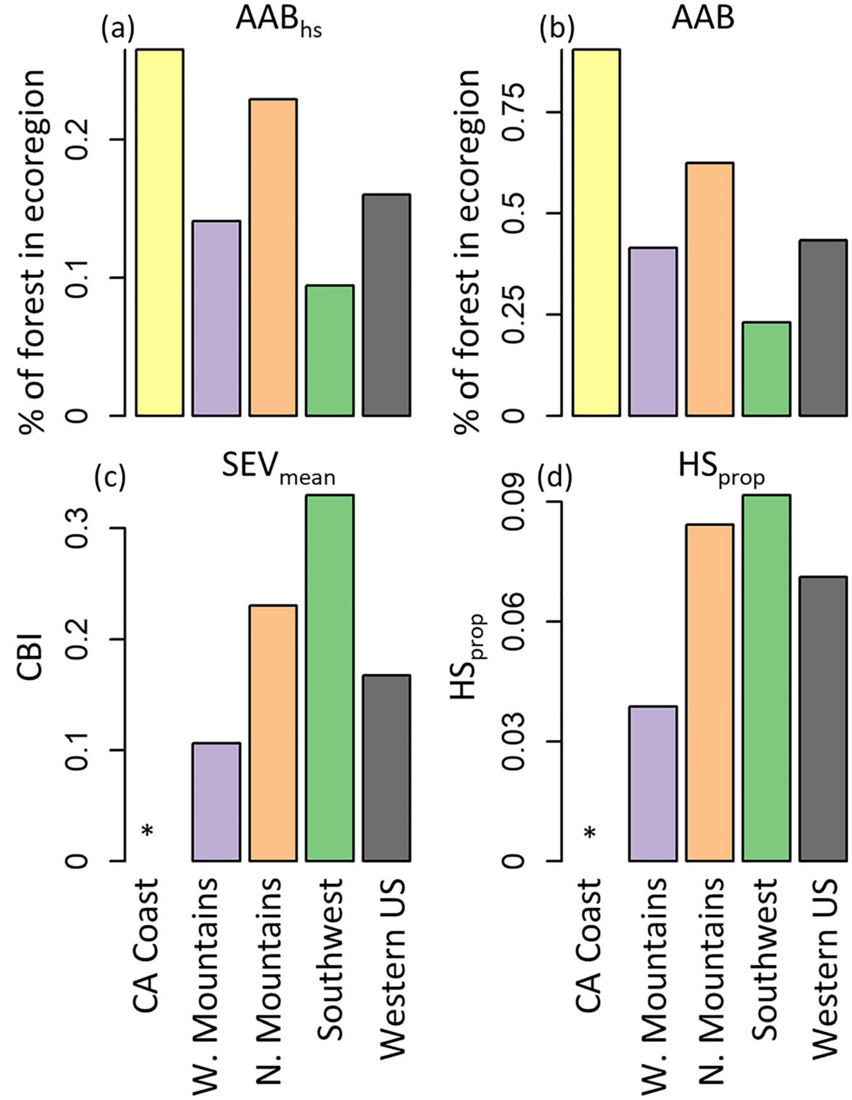


Figure 3. Increase in AAB_{hs} (a) and AAB (b) estimated with change in fire-season mean maximum vapor pressure deficit (VPD_{max}) z-score from 0 to 1. Estimates of increasing AAB_{hs} and AAB were then converted to percentage of forest in each ecoregion to facilitate comparisons among ecoregions. These seemingly small percentages translate into very large areas (see Figure S2). AAB_{hs} and AAB were log-transformed for modeling purposes, as previously described, so their relationship to climate is nonlinear. This indicates that larger increases in AAB_{hs} and AAB will be expected when fire season z-scores are higher (e.g., z-score = 0.5 vs. 1.5). Increase in SEV_{mean} (c) and HS_{prop} (d) for each z-score unit increase in fire-season VPD_{max}. AAB: annual area burned; AAB_{hs}: annual area burned at high severity; HS_{prop}: proportion burned at high severity; SEV_{mean}: annual mean fire severity; asterisk (*) indicates$p > 0.05$.

through these metrics (Ficklin & Novick, 2017; Williams et al., 2013) will continue to increase AAB_{hs} and AAB where fuels remain abundant. Although temporal trends in SEV_{mean} and HS_{prop} were less evident, these fire severity metrics were clearly elevated in warmer and drier fire seasons across most ecoregions and in broader western US forests. Again, this suggests that future climate warming may result in increased fire severity as characterized by SEV_{mean} and HS_{prop}, and consequently, trends in these fire severity metrics may emerge in future years as the climate continues to warm.

In conducting this study, we build and expand on previous fire severity studies (Abatzoglou et al., 2017; Dillon et al., 2011) and provide an assessment of fire severity parallel to those who evaluated variability in AAB across the western US (e.g., Abatzoglou & Williams, 2016; Dennison et al., 2014; Holden et al., 2018). Although the observed increases in AAB_{hs} largely reflect increases in AAB (Figure 1), there is some quantitative evidence that fire severity per se has increased in some ecoregions independent of increases in AAB, in that SEV_{mean} and HS_{prop} have increased in the Northern Mountains and Southwest ecoregions, respectively (Figure 2). Our finding that there is only limited evidence in increasing fire severity (as measured by SEV_{mean} and HS_{prop}) is consistent with previous fire severity studies encompassing the western US (i.e., Dillon et al., 2011; Picotte et al., 2016) which showed that increases in severity were limited to specific ecoregions or vegetation types. Likewise, our finding that AAB_{hs} and HS_{prop} increased in the southwestern ecoregion is consistent with the findings of Singleton et al. (2019) who conducted their study in Arizona and New Mexico.

The increases in AAB_{hs}, and to a lesser degree SEV_{mean} and HS_{prop}, documented in this study have profound implications to forest ecosystems. In severely burned forests, for example, some tree species such as ponderosa pine and Douglas fir are much less likely to reestablish when distance to live tree (as a seed source) exceeds ~100 m (Chambers et al., 2016; Kemp et al., 2016). All things being equal, more high-severity fire will result in increased distance to live trees (cf. Collins et al., 2017), lower probability of successful postfire seedling establishment, thus increasing the area at risk of fire-facilitated conversion to nonforest. The constraints imposed by available seed source are compounded by postfire climate conditions that are becoming increasingly unsuitable for successful seedling survival (Davis et al., 2019; Kemp et al., 2019; Stevens-Rumann et al., 2018). As AAB_{hs} continues to increase as the climate warms, as suggested by our results, fire-catalyzed conversions from forest to alternative forest types or nonforest may be expected to become more common (Coop et al., 2020; Parks, Dobrowski, et al., 2019).

The increasing prevalence of area burned at high severity documented in this study also has important consequences to several other ecosystem attributes. For example, species that are adapted to fire regimes characterized by low- and moderate-severity fire (e.g., California spotted owl) are known to avoid large patches of severely burned forest (Jones et al., 2020). High-severity fire also increases soil erosion, runoff, and sediment yields (Benavides-Solorio & MacDonald, 2001; Robichaud & Waldrop, 1994; Spigel & Robichaud, 2007) and has multidecadal impacts on soil biochemistry (Dove et al., 2020). High-severity fire also decreases forest carbon stability (Hurteau & Brooks, 2011), and given that forests store more carbon than nonforest (Ruesch & Gibbs, 2008), observed and projected fire-catalyzed shifts from forest to nonforest (Coop et al., 2020; Liang et al., 2017; Serra-Diaz et al., 2018) thus imposes a positive feedback that further increases atmospheric CO_2 concentrations and climate warming.

Although temporal trends in SEV_{mean} and HS_{prop} were less evident compared to trends in AAB_{hs} and AAB, there are some inherent difficulties in summarizing fire severity in this manner. For example, individual years with low area burned can result in outliers when calculating SEV_{mean} and HS_{prop}, thereby making trends difficult to identify. Furthermore, differences in terms of the characteristic fire severity of specific vegetation types that is confounded by spatial differences in where fires occur within an ecoregion make metrics such as SEV_{mean} and HS_{prop} difficult to analyze. For example, a given ecoregion may have a particularly active fire year in higher elevation forests, which typically have higher overall fire severity (Agee, 1993), and in a different year, the fires may be concentrated in lower elevation drier forests, which typically have lower severity fire. These spatial differences may obfuscate annual fire severity metrics such as SEV_{mean} and HS_{prop} when evaluating large ecoregions and western US forests as a whole and could partially explain why there is not a clear scientific consensus regarding temporal trends in fire severity (cf. Miller & Safford, 2012; Mueller et al., 2020; Picotte et al., 2016).

Our finding of reduced fire severity (SEV_{mean} and HS_{prop}) in cooler and wetter fire seasons provides some guidance to managers as society struggles to better coexist with fire (McWethy et al., 2019; Moritz et al., 2014). For example, it may be possible to increase the prevalence of low- and moderate-severity fire, sometimes referred to as "good fire" (Doerr & Santín, 2016), through thoughtful planning about where and when to implement a less aggressive fire suppression response. Similar to prescribed fires that consume fuel and promote forest resilience, unplanned fires that burn during less-than-extreme fire seasons have the potential to serve as effective "fuel treatments" that lower the probability of subsequent high-severity fire, even if the subsequent fire occurs under extreme burning conditions (Stoddard et al., 2020; Walker et al., 2018). Indigenous knowledge (Lake et al., 2017; Wynecoop et al., 2019) and lessons learned from wilderness and prescribed fire programs (Collins et al., 2007; Holsinger et al., 2016; Hunter & Robles, 2020) can potentially help land managers promote more good fire in western US forests.

Data Availability Statement

The following gridded data sets have been archived and are available online (https://doi.org/10.5061/dryad.tmpg4f4x1): (1) fire severity and prefire NDVI, (2) monthly CWD, and (3) the forest mask. Monthly VPD_{max} and T_{max} data were obtained from the PRISM Climate Group, Oregon State University (http://prism.oregonstate.edu). Fire perimeters were obtained from the Monitoring Trends in Burn Severity Program (Eidenshink et al., 2007; http://mtbs.gov).

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