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INVITED COMMENTARY

Wet-to-Dry Cascades May Increasingly Drive Wildfire Activity in Non-Forested Ecosystems, and Further Amplify the Risk of Urban Interface Fire Disasters, in a Warming Climate

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It has long been recognized that antecedent weather and climate conditions strongly modulate wildfire activity across a wide range of ecosystems and vegetation types. On short timescales, low humidity and high wind conditions can favor fast-spreading and high-intensity fires if fuel conditions align. In the long term, increasing mean state and/or extreme episodic vegetation aridity—caused primarily by rising evaporative demand from warming temperatures—has broadly increased the occurrence of extreme burning conditions in wildfire-prone regions globally (Jain et al. 2022), with further escalation expected as warming continues (Cunningham et al. 2025). Accordingly, in recent years, both short- and long-term meteorological data have increasingly been used to make forward-looking predictions regarding local to global-scale wildfire for purposes ranging from land management to emergency response to actuarial risk assessment.

Yet there is also evidence that vegetation response to climate variability and change is not always as straightforward as "drier equals more flammable." This is particularly true in so-called "fuel-limited" settings—namely, ecoregions dominated by grass and shrubs—in which overall biomass varies considerably as a function of landscape-scale moisture availability between seasons and across years. In such settings, active fire years often follow anomalously wet (versus dry) periods following episodes of accelerated plant growth (Keeley 2004).

This reality has come into particular focus in the aftermath of the devastating Southern California wildfires in January 2025, which burned primarily in dense woody shrubland (locally known as chaparral) and grassland during an extreme downslope windstorm and caused at least 30 direct deaths and the destruction of over 16,000 homes and other structures. Preceding the fires, the region had experienced a relatively brief (~6 month) but exceptionally intense dry period, though it was not yet experiencing multi-year drought conditions due to the occurrence of an anomalously wet period over the 2 years immediately preceding the fires. Instead, the observed sequence of extremely wet to extremely dry conditions allowed, first, for rapid biomass accumulation as grass and shrubs took advantage of favorable growing conditions, and then subsequently for rapid drying of this unusually abundant vegetation—culminating in a historically flammable precondition when strong winds eventually arrived (Swain, Prein, et al. 2025).

In a recent analysis, McNorton et al. (2025) explore this striking temporal evolution and its implications for wildfire risk in much greater detail–demonstrating the importance of a wet-to-dry "moisture cascade" not only in driving extreme fire activity during this specific January 2025 episode but also more generally during other extreme wildfire events throughout California between 2012 and 2025. The authors find that while the observed intensity of fires in fuel-dense mountainous forest regions progressively increases with antecedent dryness, high-intensity fires in non-forest ecoregions (specifically, scrub and grass-dominated Mediterranean and desert biomes) are instead consistently preceded by a distinct "1–2 punch" consisting of an anomalously wet period (6 months to 2 years in advance) followed by an anomalously dry period (within 6 months). These pronounced wet-to-dry episodes, which the authors term "hydroclimate rebound" events, allow for a potentially volatile combination of unusually high fuel loading and unusually low fuel moisture–setting the stage for fast-moving and high-intensity fires given an ignition amid adverse weather conditions.

While McNorton et al. (2025) consider only wildfires occurring in California, it is plausible that the underlying atmosphere–biosphere dynamics that underpin extreme fire episodes following "hydroclimatic rebound" events are generalizable to fuel-limited settings globally. Fuel accumulation-to-desiccation cycles following wet-to-dry hydroclimate sequences have previously been linked to increased wildfire activity or severity in regions characterized by extensive grassland and/or shrubland vegetation (Swetnam et al. 2016)—as well as in transitional ecosystems with a substantial grass/shrub component (e.g., savannah or woodland) and in deserts (where vegetation is often sparse/spatially discontinuous but responds quickly to occasional moisture increases). Thus, while further research in other regions will be needed for confirmation, the lessons learned from this California-centric study can probably be extrapolated to other subtropical, semiarid, and/or "Mediterranean-like" climate zones globally. Moreover, as landscape-scale disturbances (including high-intensity fires) facilitate increasingly widespread vegetation "type conversions," often from forest to shrubland or shrubland to grassland (Guiterman et al. 2022), the spatial footprint of moisture-responsive vegetation is itself likely expanding to new areas—possibly causing a self-reinforcing positive feedback.

The potential global relevance of these findings is especially notable considering growing evidence that the deadliest and most destructive contemporary wildfires tend to occur not in forests, but instead in the grasslands, savannahs, and shrublands common in semiarid settings (Balch et al. 2024). These so-called "fast fires"—which are responsible for a highly disproportionate fraction of structure loss in the wildland–urban interface (WUI) and have served as the catalyst for multiple recent mass urban conflagrations—can be rapidly propelled through fine fuels by strong wind events. It is in precisely these types of settings, characterized by a high prevalence of moisture-responsive grass and shrubs, where the "hydroclimate rebound" effect identified by McNorton et al. (2025) is likely to be most pronounced.

Widespread and substantial increases in potential fire intensity are expected globally with as little as 1.5°C–2.0°C of global warming, and early observational evidence of such increases has already emerged in some ecoregions (Cunningham et al. 2025). Much of these observed and projected increases in wildfire intensity and size stem from increased vegetation dryness, which is strongly (and intuitively) linked with increased fire activity in "moisture-limited" settings, namely forests (Abatzoglou et al. 2021). Yet comparatively little attention has been paid to the potential for increasing hydroclimate volatility (Swain, Abatzoglou, et al. 2025; Swain, Prein, et al. 2025) to amplify fuel accumulation–desiccation cycles in non-forest ecosystems beyond what increasingly extreme aridity maxima might imply. Thus, increased frequency and intensity of wet-to-dry "whiplash" might represent an additional, and historically underrecognized, mechanism through which wildfires in certain ecoregions can further intensify on a warming Earth. Given that the greatest near-term projected wildfire intensification is anticipated to occur in or near high exposure WUI regions globally, which share considerable spatial overlap with semiarid grassland and shrubland in western North America, the Mediterranean basin, coastal Chile, and southeastern Australia (Cunningham et al. 2025), cascading biosphere-to-atmosphere effects from pronounced wet-to-dry sequences have the potential to amplify wildfire intensity precisely in those settings most at risk of catastrophic loss of life and property during such events.

Thus, the "hydroclimatic rebound" paradigm highlighted by McNorton et al. (2025) is not merely of academic importance. There is presently great interest, among entities both public and private, in generating accurate forward-looking wildfire risk estimates over a wide range of time scales. Improving shorter-term seasonal to multi-annual predictions would enable communities and governments to make informed land management and emergency response-related decisions to manage risk (e.g., in identifying windows of opportunity for prescribed fire implementation and regarding optimal allocation of firefighting resources). More accurately quantifying multi-decadal trends could better align long-term climate adaptation planning with on-the-ground realities, improving the wildfire resilience of communities and also allowing for more sophisticated estimates of potential catastrophic risk needed to ensure stable insurance (and reinsurance) markets. The incorporation of potential "hydroclimate rebound" signals in relevant ecoregions–which to our knowledge remain largely absent in both academic and industry wildfire models–could yield a substantial advance in the ability of such frameworks to provide credible estimates of both baseline and future risk. And in some instances, the wet-to-dry "hydroclimate rebound" signature identified by McNorton et al. (2025) may even have the potential to serve as a heretofore underutilized "early warning" indicator regarding upcoming periods of regionally elevated wildfire risk up to 2 years in advance.

Finally, we emphasize that these findings offer a striking example of the need to "think beyond the mean" in the context of climate change and its societal and ecological impacts. In the specific case of California wildfire, McNorton et al. (2025) find that the particular temporal sequence of weather and climate leading up to extreme wildfire events matters at least as much, if not more, than the time-mean precipitation and temperature in non-forest ecosystems. While accumulated dryness over longer periods is clearly still a key driver of wildfire risk in forested regions, it may not be adequate to understand variability and trends in wildfire risk in non-forested settings. This kind of result–involving the behavior of a dynamically complex coupled system that cannot be directly inferred from knowledge of its mean state or not even its secular long-term trend–challenges conventional assumptions that simply extracting annual or seasonal mean values (or their linear trends) from observational or climate model datasets is adequate to characterize observed or future changes in non-mean state conditions (Swain, Abatzoglou, et al. 2025; Swain, Prein, et al. 2025). The findings of McNorton et al. (2025) should, therefore, offer a clear example to both producers and users of climate data regarding the importance of preserving the underlying temporal structure of climate and land surface/ecological variables, and of ensuring that subsequent modeling efforts are capable of retaining that temporal structure when generating forward-looking predictions. Doing so will reduce the likelihood of underestimating the risks associated with wildfire and other geohazards, and thus the risk of making suboptimal decisions due to incorrectly inferred trends, in the complex and nonstationary context of a warming climate.

Author Contributions

Daniel L. Swain: conceptualization, project administration, supervision, writing – original draft, writing – review and editing. **Jilmarie J. Stephens:** conceptualization, writing – review and editing.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analyzed for the current article.

Linked Articles

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