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CORRIGENDUM

Corrigendum: Tree mortality from fires, bark beetles, and timber harvest during a hot and dry decade in the western United States (2003–2012) (2017 Environ. Res. Lett. 12 065005)

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Corrigendum abstract

We discovered an error in our analysis that led us to underestimate tree mortality from fires and beetles in western California and northern Washington. We characterized fire extent and severity using the Monitoring Trends in Burn Severity raster mosaic data set. This data set did not maintain a consistent spatial extent across years, but rather the annual spatial extent encompassed all fires that occurred in a specific year. The data set thus periodically excluded parts of western California and northern Washington when no fires occurred in those areas. We did not adequately account for no-data values that were introduced by shifts in annual spatial extent of these data. The no-data values were then propagated through the analysis when we updated the biomass map at each time-step to account for prior tree mortality. Functionally, the biomass map were iteratively nibbled away by no-data values along the western and northern edges of the study domain, causing us to underestimate tree mortality in these areas. We corrected this error and updated our estimates of statewide tree mortality. Our estimates of mean annual tree mortality from fires increased from 2.60 ± 2.14 to 2.73 ± 2.43 Tg AGC yr⁻¹ for California and from 0.52 ± 0.38 to 0.80 ± 0.78 Tg AGC yr⁻¹ for Washington. Similarly, our estimates of mean annual tree mortality from beetles increased from 1.65 ± 0.95 to 1.71 ± 1.01 Tg AGC yr⁻¹ for California and from 1.64 ± 0.45 to 2.47 ± 0.77 Tg AGC yr⁻¹ for Washington. We updated our estimates of tree mortality in table S2 and where referenced in the abstract and results. We also updated our corresponding tree mortality data set that is archived on the Oak Ridge National Laboratory Distributed Active Archive System. Overall, this correction did not change the conclusions of our paper and we apologize for any inconvenience.

Abstract

High temperatures and severe drought contributed to extensive tree mortality from fires and bark beetles during the 2000 in parts of the western continental United States. Several states in this region have greenhouse gas (GHG) emission targets and would benefit from information on the amount of carbon stored in tree biomass killed by disturbance. We quantified mean annual tree mortality from fires, bark beetles, and timber harvest from 2003–2012 for each state in this region. We estimated tree mortality from fires and beetles using tree aboveground carbon (AGC) stock and disturbance data sets derived largely from remote sensing. We quantified tree mortality from harvest using data from US Forest Service reports. In both cases, we used Monte Carlo analyses to track uncertainty associated with parameter error and temporal variability. Regional tree mortality from harvest, beetles, and fires (MORTH) together averaged 47.1 ± 17.1 Tg AGC yr⁻¹ (±95% confidence interval), indicating a mortality rate of 1.13 ± 0.41% yr⁻¹. Harvest accounted for the largest percentage of MORTH (49%), followed by beetles (33%), and fires (18%). Tree mortality from harvest was concentrated in Washington and Oregon, where harvest accounted for 68%–83% of MORTH in each state. Tree mortality from beetles occurred widely at low levels across the region, yet beetles had pronounced impacts in Colorado and Montana, where they accounted for 53%–93% of MORTH. Tree mortality from fires was highest in California, though fires accounted for the largest percentage of...
MORT\textsubscript{H+B+F} in Arizona and New Mexico (~50%). Drought and human activities shaped regional variation in tree mortality, highlighting opportunities and challenges to managing GHG emissions from forests. Rising temperatures and greater risk of drought will likely increase tree mortality from fires and bark beetles during coming decades in this region. Thus, sustained monitoring and mapping of tree mortality is necessary to inform forest and GHG management.

**Results**

**Regional tree mortality from disturbance**

Taken together, mean annual tree mortality from timber harvest, bark beetles, and fires (MORT\textsubscript{H+B+F}) was 47.1 ± 17.1 Tg AGC yr\(^{-1}\) from 2003–2012 across the western US. Regional tree AGC stocks totaled 4.16 ± 0.12 Pg, suggesting that the tree mortality rate was 1.13 ± 0.41% yr\(^{-1}\). Timber harvest accounted for the largest percentage of MORT\textsubscript{H+B+F} (49%), followed by bark beetles (33%) and then fires (18%, figure 3, table S2).

**Tree mortality from fire**

Mean annual tree mortality from fires (MORT\textsubscript{fire}) was 8.6 ± 6.9 Tg AGC yr\(^{-1}\) and the mortality rate was 0.21 ± 0.17% yr\(^{-1}\) from 2003–2012 in the western US (figures 3, 4(a), 5, table S2). Absolute MORT\textsubscript{fire} was highest in northern California, central Idaho, and western Montana, with these states accounting for 63% of regional MORT\textsubscript{fire}. Forests in Arizona and New Mexico experienced the highest annual rates of MORT\textsubscript{fire} (0.36%–0.57% yr\(^{-1}\)), as well as the highest percentage of MORT\textsubscript{H+B+F} caused by fire (51–55%). Conversely, forests in Colorado, Oregon, and Washington had the lowest rates of MORT\textsubscript{fire} (0.03%–0.10% yr\(^{-1}\)) and the lowest percentage of MORT\textsubscript{H+B+F} caused by fire (2%–8%). Fires that occurred in Oregon and Washington were largely concentrated along the eastern slopes of the Cascade Range.

**Tree mortality from bark beetles**

Mean annual tree mortality from bark beetles (MORT\textsubscript{beetle}) was 15.5 ± 7.4 Tg AGC yr\(^{-1}\) and the mortality rate was 0.37 ± 0.18% yr\(^{-1}\) from 2003–2012 in the western US (figures 3, 4(b), 5, table S2). Absolute MORT\textsubscript{beetle} was highest in northern Colorado, western Montana, and central Idaho, with these states accounting for 49% of regional MORT\textsubscript{beetle} (table S2). Forests in Colorado and Wyoming had the highest annual rates of MORT\textsubscript{beetle} (1.12%–1.22% yr\(^{-1}\)) and the highest percentage of MORT\textsubscript{H+B+F} caused by bark beetles (80%–93%). Conversely, Oregon and Washington had not only two of the lowest rates of MORT\textsubscript{fire}, but also two of the lowest rates of MORT\textsubscript{beetle} (0.10%–0.30% yr\(^{-1}\)).

**Tree mortality from timber harvest**

Mean annual tree mortality from timber harvest (MORT\textsubscript{harvest}) was 23.0 ± 2.8 Tg AGC yr\(^{-1}\) and the mortality rate was 0.55 ± 0.07% yr\(^{-1}\) from 2003–2012 in the western US (figures 3, 5, table S2). Timber harvest in Oregon and Washington accounted for 67% of regional MORT\textsubscript{harvest}. These two states had the highest rates of MORT\textsubscript{harvest} (0.85%–0.86% yr\(^{-1}\)) and the highest percentage of MORT\textsubscript{H+B+F} caused by harvest (68%–83%). Conversely, forests in Colorado, Utah, and New Mexico had the lowest rates of MORT\textsubscript{harvest} (0.04%–0.06% yr\(^{-1}\)) and among the lowest percentage of MORT\textsubscript{H+B+F} caused by harvest (3%–10%).

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