Response to 'Letter to the editor regarding Rodrigues et al. 2020: Is COVID-19 halting wildfires in the Mediterranean? Insights for wildfire science under a pandemic context'

Marcos Rodrigues¹,²*, Pere J. Gelabert¹,², Aitor Ameztegui¹,², Lluis Coll¹,², Cristina Vega-García¹,²

¹Department of Agricultural and Forest Engineering. University of Lleida. Alcalde Rovira Roure 191, 25198, Lleida, Spain

²Joint Research Unit CTFC-Agrotoecnio. Ctra. Sant Llorenç de Morunys, km 2, 25280, Solsona, Lleida, Spain

* Marcos Rodrigues; marcos.rodrigues@udl.cat
In our work, we presented a preliminary analysis of the potential impacts in wildfires of the societal and public health response to COVID-19 during the lockdown period (Rodrigues et al., 2020). We focused on the winter-spring period, when the lockdown was decreed, and on the Mediterranean region, where human activity is known to be responsible for most of fire activity (Costafreda-Aumedes et al., 2018). Note that at the time we conducted the analysis no information was available about fire activity in summer months so our findings must be properly framed in the March-May period. In that regard, the commentary by Resco de Dios refers to an “online first” version of the manuscript, but in the proof editing process we already suggested a slight modification of the title to help framing our work “Has COVID-19 halted winter-spring wildfires in the Mediterranean? Insights for wildfire science under a pandemic context”. The question addressed in our Short Communication is not whether the year 2020 had higher or lower fire activity. It is to what extent lockdowns and curfews could halt (in the sense of interrupting) wildfire activity when in place, but warning about the forthcoming undesired effects of concatenating successive seasons with reduced fire activity (regardless it comes from lack of ignition sources or unfavorable environmental conditions for fire ignition and spread). That being said, the main points Resco de Dios is raising relate to summer fire activity so we find his answer complementary to our results but cannot see it as a replica, as it does not relate to our analyses or statements.

In his commentary, Resco de Dios stated that we “assumed that the main drivers of burned area in the region are either human activity or drought” and that “assuming that drought is the main driver of fire activity is problematic”. We must stress that in our communication we haven’t assumed that, in any case. We presumed that winter-spring fires in the Mediterranean region associate to human activity (Costafreda-Aumedes et al., 2018) and we provided a drought-related index (SPEI) to contextualize the yearly comparisons and address the weather circumstances each season (year) underwent. Several works support the use of SPEI as a proxy for thermal and pluviometric anomaly; and Resco de Dios himself has used SPEI for the same purposes we did in the recent work by Nolan et al. (2020), referring to the 2019-2020 extreme fire wave in Australia. Our main assumption is that human activity is the central driver of winter-spring fires (though i.e. winds and plant physiology play an important role as well), thus the cessation in human activity might lead to lower fire incidence. We are fully aware that fire activity is driven by a combination of factors varying spatially and temporally with varying influence. This is specified in our work in different places: “Since wildfires are triggered by the combination of human ignition sources and environmental factors...”; “Even though other factors might be mediating...” (Rodrigues et al., 2020).

Likewise, we feel the correlation analysis conducted in Resco de Dios is overly simplistic. In our work, we reported the dispersion value (standard deviation) of the SPEI as an indicator of the spatial variability of SPEI in the region (see Table 1). Thus calculating a correlation coefficient or fitting a model from mean SPEI and burned area on a yearly basis to infer anything is misleading. Moreover, the shape of the relationship it is not necessarily linear, as we believe Resco de Dios assumed in his calculations. In any case, if one would proceed and model the relationship between SPEI and burned area with such a limited number of years, it would be more appropriate log transforming (i.e., log-linear model) the dependent variable (BA) so it is closer to a normal distribution and prompts a non-linear relationship. Under such conditions, the log-linear model
attains an $R^2$ of 0.22 and, more important, a significant p-value of 0.049. The low $R^2$ has to be expected, since SPEI is not the only driver of wildfires.

On a secondary note, one can argue that including 2020 in these models is not entirely appropriate since we hypothesized that it may be an anomalous record, thus potentially biasing regression outputs. If we take away that observation, $R^2$ raises to 0.37 while the p-value is clearly below 0.05 (p=0.009). Thus, it is clear the relation between SPEI (as an indicator of drought anomaly) and BA (Fig. 1).

We respectfully disagree from Resco de Dios “that the number of ignitions in different EUMED regions is independent from burned area”, as stated in the commentary note. See for instance the work by Jiménez-Ruano et al. (2019) were an in-depth comparison among fire features and fire weather was conducted exploring the links with cause and season. The association between the number of ignitions and burned area is there. Besides, Rodrigues et al. (2013) found that trends in burned area and in number of fires do not necessarily match each other, likely due to suppression efforts (Curt and Frejaville, 2017). Moreover, some works even suggest a link between human-related fire occurrence and large fires (Costafreda-Aumedes et al., 2015; Nagy et al., 2018).

The EFFIS estimations for March-May reported by Resco de Dios are in line with our findings. According to the same EFFIS estimations for Spain -the country for which we reported the strongest decline in fire activity- it can be clearly observed how the profile of both fire ignitions (Fig. 2) and burned area (Fig. 3) flattens during the lockdown period in March-May 2020 but the 2008-2019 average kept increasing during the same period. Interestingly enough, during the second wave in Spain in the month of September, when measures against COVID-19 were starting again in some regions, the profile has become flat again in 2020 while the former years' trend is still increasing until October.

Finally, Resco de Dios states that “the reason underlying the low burned area in 2020 awaits further testing, the mechanism is more likely related to this year's fire weather and fuel availability than to any COVID-19 related impacts on human activity and ignitions”. Again, this statement seems to refer to the entire season 2020 while our work focused on a very specific lockdown period (March-May). In fact, having inspected the weekly profiles (Fig. 2 and Fig. 3) we can reassure that the measures took to fight COVID-19 are having some effect again in late summer, where the 2nd wave of COVID-19 infection struck again in Spain, though further testing is required.

Nonetheless, we would like to reinforce our agreement in the fact that other factors govern the extent of fires during the main fire season. Our extended findings suggest that fuel-related and weather features mainly control burned area in summer, but outside the summer fire season anthropic factors that limit ignitions greatly influence the burned area output. Nonetheless, the actual effect of COVID-19 on the summer season remains pending of analysis, since curfews were withdrawn in most European countries and analyzing a single season is not sufficient to draw undeniable conclusions. Therefore, we agree further testing is required, using for instance fire statistics documented by each country or examining specific events related to fuel moisture, winds or episodic heat waves.
References

Costafreda-Aumedes, S., Cardil, A., Molina, D., Daniel, S., Mavsar, R., Vega-Garcia, C., 2015. Analysis of factors influencing deployment of fire suppression resources in Spain using artificial neural networks. iForest - Biogeosciences For. 008, e1–e8. https://doi.org/10.3832/ifor1329-008

Costafreda-Aumedes, S., Vega-Garcia, C., Comas, C., 2018. Improving fire season definition by optimized temporal modelling of daily human-caused ignitions. J. Environ. Manage. 217, 90–99. https://doi.org/https://doi.org/10.1016/j.jenvman.2018.03.080

Curt, T., Frejaville, T., 2017. Wildfire Policy in Mediterranean France: How Far is it Efficient and Sustainable? Risk Anal. 38, 472–488. https://doi.org/10.1111/risa.12855

Jiménez-Ruano, A., Rodrigues Mimbrero, M., Jolly, W.M., de la Riva Fernández, J., 2019. The role of short-term weather conditions in temporal dynamics of fire regime features in mainland Spain. J. Environ. Manage. 241, 575–586. https://doi.org/10.1016/j.jenvman.2018.09.107

Nagy, R.C., Fusco, E., Bradley, B., Abatzoglou, J.T., Balch, J., 2018. Human-Related Ignitions Increase the Number of Large Wildfires across U.S. Ecoregions. Fire 1. https://doi.org/10.3390/fire1010004

Nolan, R.H., Boer, M.M., Collins, L., de Dios, V., Clarke, H., Jenkins, M., Kenny, B., Bradstock, R.A., 2020. Causes and consequences of eastern Australia’s 2019–20 season of mega-fires. Glob. Chang. Biol. 26, 1039–1041. https://doi.org/10.1111/gcb.14987

Rodrigues, M., Gelabert, P.J., Ameztegui, A., Coll, L., Vega-García, C., 2020. Has COVID-19 halted winter-spring wildfires in the Mediterranean? Insights for wildfire science under a pandemic context. Sci. Total Environ. 142793. https://doi.org/10.1016/j.scitotenv.2020.142793

Rodrigues, M., San Miguel, J., Oliveira, S., Moreira, F., Camia, A., 2013. An insight into spatial-temporal trends of fire ignitions and burned area in the European Mediterranean countries. J. Earth Sci. Eng. 3, 497–505.
Table 1. Summary of fire-weather data March-May in the EUMed region (2003-2020). Green shadowing indicates years similar to 2020 in terms of SPEI6 (±0.1 difference). Blue shadowing identifies years similar to 2020 in terms of burned area (most countries showing below average burned area; Z-Score < 0). Red shadowed cells mark the year 2020. Source: Rodrigues et al. (2020)

| Year | SPEI6 Mean | sd  | Burned area (ha) |
|------|-----------|-----|------------------|
| 2003 | -0.274    | 0.874 | 17,350          |
| 2004 | 0.094     | 0.739 | 9,875           |
| 2005 | -0.811    | 0.858 | 60,550          |
| 2006 | -0.373    | 0.719 | 21,300          |
| 2007 | -0.435    | 0.721 | 5,575           |
| 2008 | 0.020     | 0.714 | 11,750          |
| 2009 | -0.105    | 0.858 | 34,425          |
| 2010 | 0.649     | 0.877 | 11,075          |
| 2011 | -0.688    | 0.989 | 24,125          |
| 2012 | -0.567    | 0.853 | 41,925          |
| 2013 | 0.849     | 0.574 | 3,250           |
| 2014 | -0.046    | 0.846 | 38,800          |
| 2015 | -0.618    | 0.888 | 20,600          |
| 2016 | -0.009    | 0.945 | 10,950          |
| 2017 | -1.350    | 0.650 | 26,850          |
| 2018 | 0.588     | 0.621 | 3000            |
| 2019 | -1.060    | 0.787 | 12,175          |
| 2020 | -0.731    | 0.807 | 3,325           |
Fig. 1. Summary of log-linear models between SPEI6 and burned area. Points correspond with years. Green points indicate similar years to 2020 in terms of SPEI6 whereas blue points indicate similar years to 2020 in terms of burned area. The orange point marks the position of 2020. The black solid line shows the relationship profile SPEI6-BA including 2020, while the orange line shows the same relationship excluding 2020.
Fig. 2. Weekly distribution of number of fires in 2020 (orange) and average 2008-2019 (blue) in Spain in March-May. Green bars mark the raw difference between 2020 and the reference period. Shadowed background indicate the length and type of COVID-related measures. Data source: EFFIS and Spanish Ministry of Health.

Fig. 3. Cumulative distribution of burned area in 2020 (orange) and average 2008-2019 (blue) in Spain in March-May. Green bars mark the raw difference between 2020 and the reference period. Shadowed background indicate the length and type of COVID-related measures. Data source: EFFIS and Spanish Ministry of Health.