

# ***Interactive comment on “Fire risk modulation by long-term dynamics in land cover and dominant forest type in Eastern and Central Europe” by Angelica Feurdean et al.***

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## General comments

The manuscript by Feurdean and colleagues compiles a large dataset of charcoal and pollen records to quantify the effect of climate and vegetation on fire regimes in Central and Eastern Europe. The authors apply generalized additive models (GAMs) to explore the relationships between biomass burned and changes in climate and land cover. They conclude that tree cover is a first order predictor of fire occurrence probability and that land cover management can reduce future fire risks.

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I've greatly enjoyed reading this relevant and well-written article. However, I feel that the manuscript would profit from a more process-based view of the drivers of fire occurrence in the study region. I fully agree with the authors that tree cover is a good predictor of fire occurrence in the past, however, this does not mean that there is a direct causal link. As recognized in a vast number of paleoecological articles, climate and human impact are the main drivers of both vegetation and fire dynamics during the Holocene, with climate being the primary forcing factor during the Early Holocene and anthropogenic impact becoming increasingly dominant during the Late Holocene. Since these two drivers affect both the response variable (biomass burned) and the predictor (tree cover) a high correlation is not surprising and should not be confused with causality. Although a decrease in tree cover indeed coincides with an increase in the amount of biomass burned, I would argue that changes in tree cover are itself caused by climate (during the Early Holocene) and human impact (during the Late Holocene). I do not see any evidence that would support the claim that total forest cover has a direct effect on fire dynamics, although I do concur that the type of vegetation (broadleaf vs needleleaf) has indeed an effect. I believe that a more cautious and less simplistic phrasing of the conclusions and abstract, highlighting the direct impact of human land-use on forest cover and fire occurrence would be highly beneficial for the article and not detract from the tremendous amount of work that has been put into compiling and analyzing such a large dataset.

### Specific comments

#### Introduction:

- L.116-118: You state here that "...an increase in tree cover beyond a specific threshold can reduce fire hazard,..." , implying that tree cover itself has a direct effect on fire regimes. I agree that there is certainly a correlation, but would be very careful in assigning causation. Just in the previous sentence you mention that "...fire hazard is lowest in productive and moist regions...". From a mechanistic point of view, I would argue that the main driver in reducing fire hazards is the moist climate, which leads

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to lower flammability of fuels, and not just tree cover alone. In order not to confuse the readers I would recommend elaborating on how an increase in tree cover can lead to a reduction of fire, independent from climatic conditions (e.g. local microclimate, reduction of evapotranspiration under closed canopies, etc.).

Discussion: Fire-fuel relationship: the human impact

What I miss a bit in this subchapter is the direct link between human land-use and sedimentary charcoal records. Fire was the primary method used to convert closed forests to arable land, therefore greatly increasing the natural fire occurrence and releasing large amounts of charcoal.

- L. 391-393: I'm a bit confused here. In this sentence you state that "...the human-caused change in land-cover [...] has resulted in a decline in biomass burned." But this is contrary to your data, which clearly shows a steady increase in biomass burned during the last 3ka, when this transition to a cultural landscape occurred. However, if you refer to present-day observational data, please provide a reference and also a sense of the timescales involved. I would imagine that a decline of biomass burned due to fuel limitations as a result of the conversion of forests to arable land would only apply to the last 150 years or so, a timeframe that cannot be resolved by your millennial-scale charcoal record.

- L.402-405: From my point of view, the rise in biomass burned in the ATL ecoregion at 1.5ka coincides with a sharp increase in both grassland and arable land, indicating an intensification of land-use with the help of fire for deforestation, contrary to your statement here. I would argue that high charcoal values are a result of intensive land-use, caused by the widespread deforestation that led to the conversion of forest to arable land that started during the Bronze or Iron Age and reached its maximum during the Early modern period. A decrease in area burned due to the establishment of forest protection laws in the late 19th century will not be possible to observe due to the 500-year smoother applied to the data, but might be apparent in the raw data. However,

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after rereading this sentence a few times I realized that you might actually be referring to the period between 4 and 1.5ka. In that case, ignore my comment, but rephrase the sentence to spare other readers the same confusion.

## Conclusions

I would be very hesitant to make a direct causal link between land cover per se and biomass burned. I totally agree that you make a compelling case for a strong connection between land cover and fire hazard. However, the underlying driver of changes in land cover (and biomass burned) in the Late Holocene is, from my point of view, intensifying human impact. Although land cover can be used as a predictor of fire occurrence in the past (as you nicely show), it is less suited to derive conclusions for future management options, since the underlying drivers might change. In the future I would expect no-analogue conditions, since the combination of higher-than-present temperatures and anthropogenic land-use never previously existed.

## Technical comments:

- L. 111: "...the effect that vegetation properties have in..."
- L. 277-280: I would suggest rephrasing this sentence, since it is rather confusing with the subclause.
- L. 401: "...coincides with..."
- Figure 2C: For reasons of comparison, I would suggest to plot the needleleaf and broadleaf tree percentages on the same scale, as in the other plots.

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