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Satellite assessment of post-fire forest cover loss in Siberia and its relationship with fire characteristics

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INTRODUCTION & AIM

Wildfire is a critical environmental disturbance affecting forest dynamics, succession, and the carbon cycle in Siberian forests. During the last decade, forests of Siberia experienced a significant increase in the annual burned area. In Russian forests annual burning rate estimated as 5-7 million ha with extremes exceeding 10 million ha. The impact of fires on forests is determined by a number of factors, including fire type and intensity, forest stand species composition and age structure, soils and other conditions. This study examines the relationship between fire intensity, assessed using Fire Radiative Power (FRP), and the degree of forest disturbance, assessed through the proportion of tree cover loss.

The objectives of this study included the following:

1) analysis of the dynamics of FRP and the proportion of stand-replacement fires in Siberia;
2) assessment of the relationships between FRP and predominant tree species as well as the seasonality and duration of fires and the proportion of stand-replacement fires.

DATA and METHODS

Study area

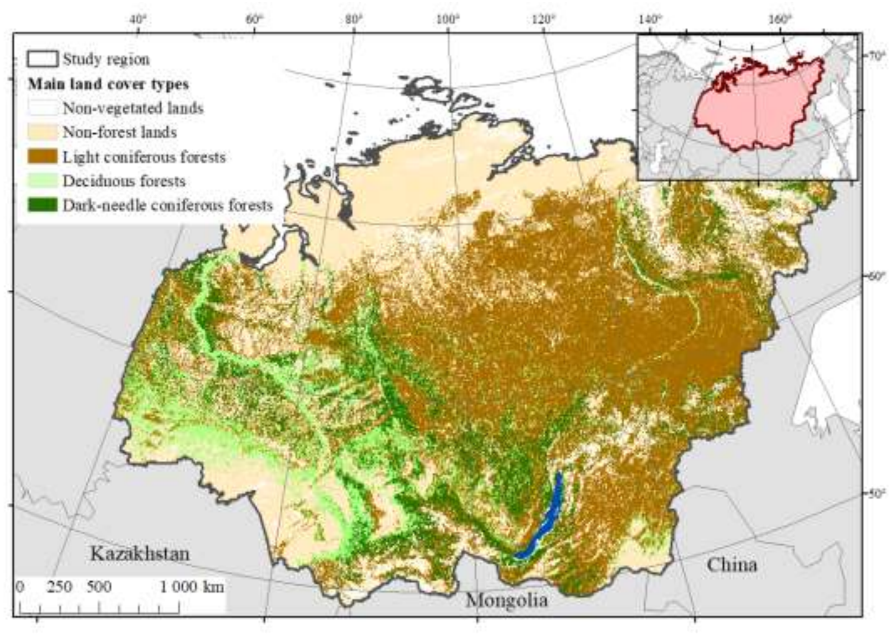

Fig. 1. Study area and main forest types

Analysis was performed for the territory of Siberia (~50–75° N and 60–160° E) with a total area of ~9.5 million km^2.

Dominant forest species:

Larch (*Larix sibirica*, *L. gmelini*) (~55% of the forest area);

Dark-needle coniferous: cedar (*Pinus sibirica*), fir (*Abies sibirica*), spruce (*Picea obovata*) (~13%);

Pine (*Pinus sylvestris*) (14%);

Deciduous species (*Betula spp.*, *Populus tremula*) (18%).

Datasets

MCD64A1 → Burned areas detection

MOD14A1 → Fire radiative power estimation

MODIS burned area and thermal anomalies products were downloaded from https://ladsweb.modaps.eosdis.nasa.gov

Vegetation map → Dominant tree species for each BA pixel

Vegetation map was obtained from the Vega service (Space Research Institute of the Russian Academy of Sciences, Moscow, http://pro-vega.ru/maps/).

Global forest change product → Detection of forest sites experienced tree cover loss

https://glad.earthengine.app/view/global-forest-change

Tree mortality was calculated as the ratio of the number of pixels in the forest change product, where tree cover loss occurred, to the total number of pixels within one pixel of the MODIS burned area product.

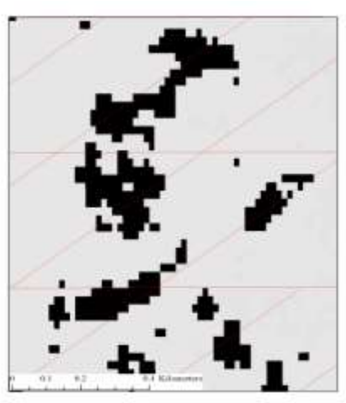

Fig. 2. Black patches indicate areas where tree mortality occurred. MODIS 500-m grid cells (burned area product) are shown in red.

RESULTS & DISCUSSION

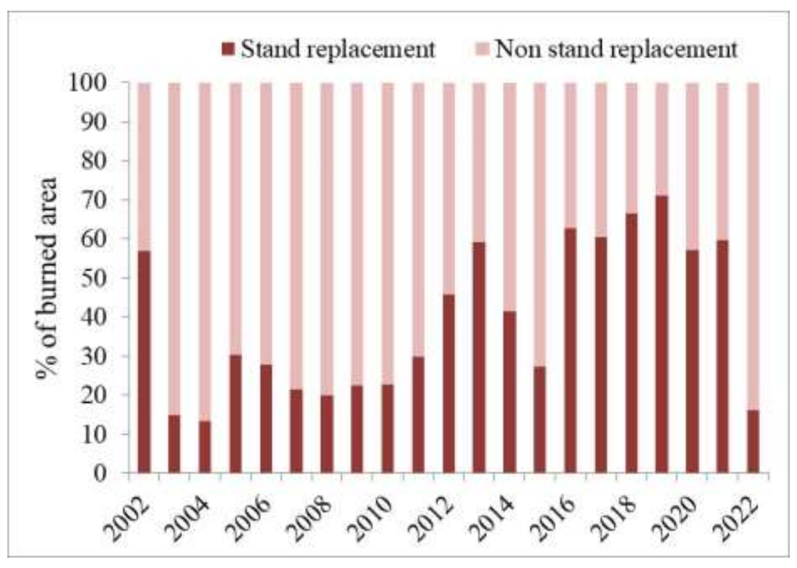

Fig. 3. Proportion of stand-replacement fires between 2002 and 2022.

Since 2012, there has been a significant increase in the stand-replacement burned area in the region. A significant trend was found for the stand-replacement burned area ($R^2 = 0.37$, $p < 0.05$).

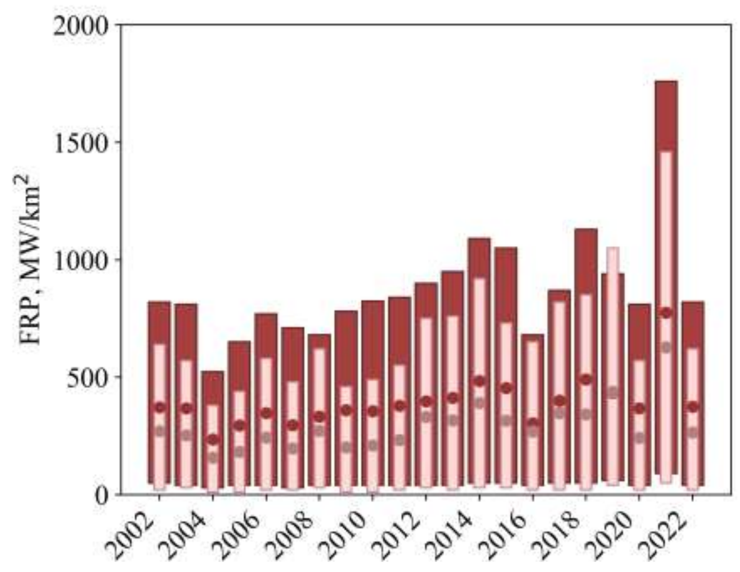

Fig. 4. Total annual FRP values. Dark red color corresponds to stand-replacement fires. Bars indicate 10-90 percentile FRP interval, dots indicate mean values.

FRP difference between stand-replacement and non stand-replacement fires was significant ($p < 0.01$). Stand replacement fires showed 33% higher mean FRP values comparing to non stand-replacement fires: 390.2±80.5 MW/km^2 vs. 291.8±74.7 MW/km^2.

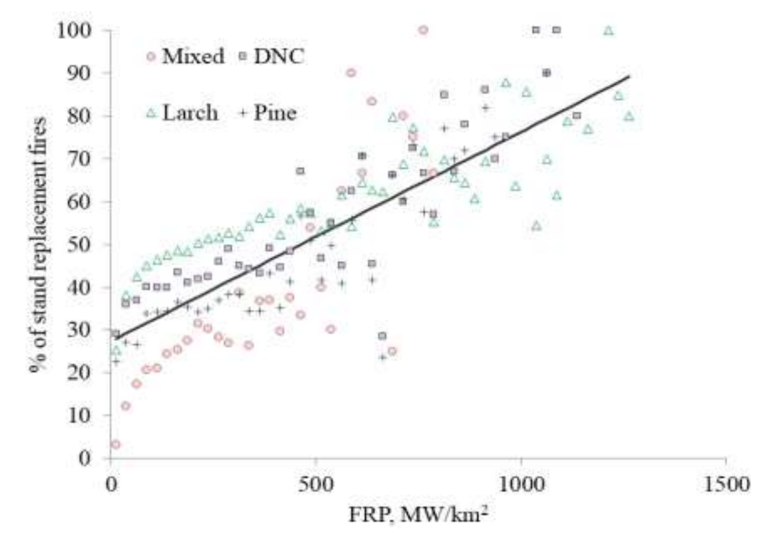

Fig. 5. Proportion on stand-replacement fire increasing with mean FRP value.

FRP had a good correlation with the proportion of stand-replacement fires for all dominant forest types. Linear regression describing dependence between two variables was $P(FRP) = 0.05 * FRP + 27.4$ ($R^2 = 0.88$, $p < 0.01$), where P is the proportion of stand replacement fires.

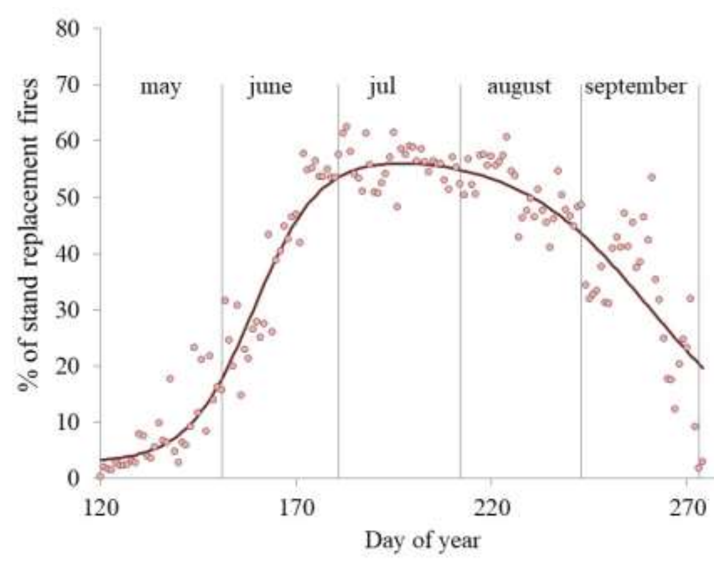

Fig. 6. Seasonal dynamics of stand-replacement fires.

Seasonal dynamics of stand-replacement fires shows a rapid increase during June (from 20 to 50%), reaching maximum of ~50–60% in July and then decreasing during August and September. The dynamics of stand-replacement fires well fitted by a logistic function.

CONCLUSION

Over the past two decades, there has been an increase in the intensity of fires and the proportion of species-changing fires in Siberia. Under climate change conditions, the number of species-changing fires is likely to continue to increase.

FUTURE WORK / REFERENCES

Hansen M.C., Potapov P.V., Moore R., et al. High-Resolution Global Maps of 21st-Century Forest Cover Change. Science, 2013, 342

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