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Seasonal Variation in Fraction of Absorbed PhotosyntheticallyActic Radiation and Vegetation Properties in Burned Forests in Interior Alaska

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INTRODUCTION

Fraction of absorbed photosynthetically acrive radiation (FAPAR) is an important ecophysiological parameter for carbon and water exchange modeling. However, validation studies of FAPAR are scarce, especially for disturbance area. One study (Steinberg et al., 2006) revealed that the MODIS FAPAR product is overestimated for burned boreal forests. Wildfire is a major disturbance in boreal forest ecosystems, and it significantly influences carbon and water exchange processes. It is important to explicitly incorporate burned areas in estimating regional exchanges.

This study aims to provide a validation data for FAPAR by collecting data regarding absorption of photosynthetically active radiation (PAR) in burned boreal forests. It also focuses on obtaining an empirical relationship to estimate seasonal and interannual variations in FAPAR from vegetation indices in the early stage of recovery after wildfire.

SITE AND OBSERVATION

■ Study sites

Two burned black spruce forests (one- and six-year old after wildfire, Fig. 1, 2 and Table 1) in Interior Alaska.

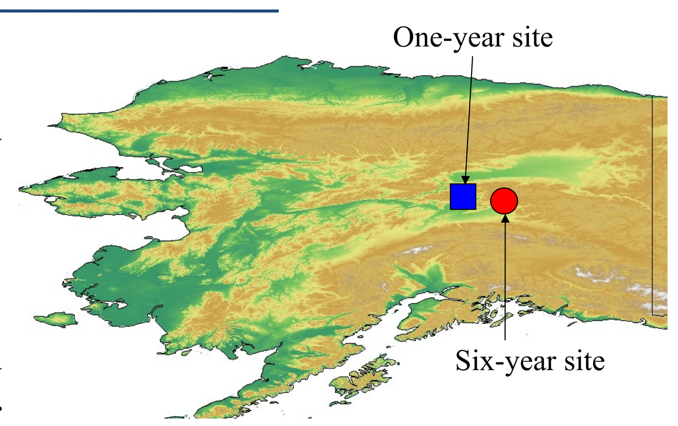


Fig. 1. Location of the study sites

■ Field sampling design (Fig. 3)

The following variables were observed approximately every two weeks at the six-year site and occasionally at the one-year site.

- Fraction of transmitted PAR (●)
- Vegetation cover based on photographs (●)
- Vegetation index (FieldSpec, ●)
- LAI (LAI-2000, ●)

Incident PAR (PAR_{in}) and reflected PAR (PAR_r) were continuously observed at an observation mast at the both sites.

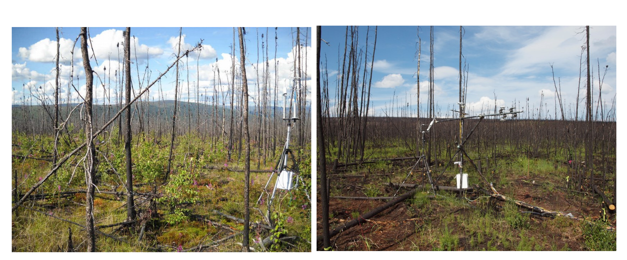


Fig. 2. Photos of the six-year (left) and one-year site (right)

Table 1. Dominant vegetation at the study sites

Site	Dominant vegetation
One-year site	sedge, prickly rose, bog blueberry, cloudberry, horsetail
Six-year site	white birch, trembling aspen, Labrador tea, bog blueberry, sedge, purple horn-toothed moss

■ Measurements and analysis

Fraction of transmitted PAR (PAR_{tr}) was observed with a line PAR sensor (LI191SA). It did not account for absorption of PAR by mosses (Fig. 4).

$$FAPAR = 1 - \frac{PAR_r}{PAR_{in}} - \frac{PAR_{tr}}{PAR_{in,manual}}$$

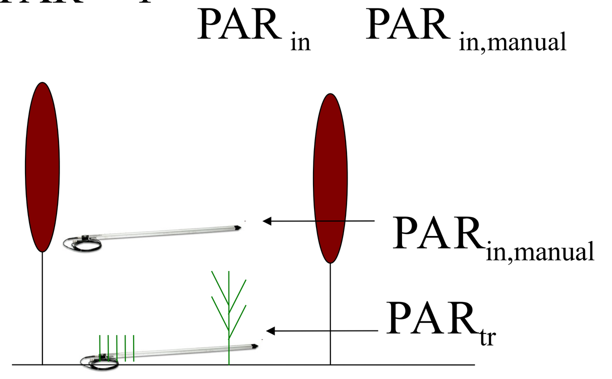


Fig. 4. Measurement of fraction of transmitted PAR

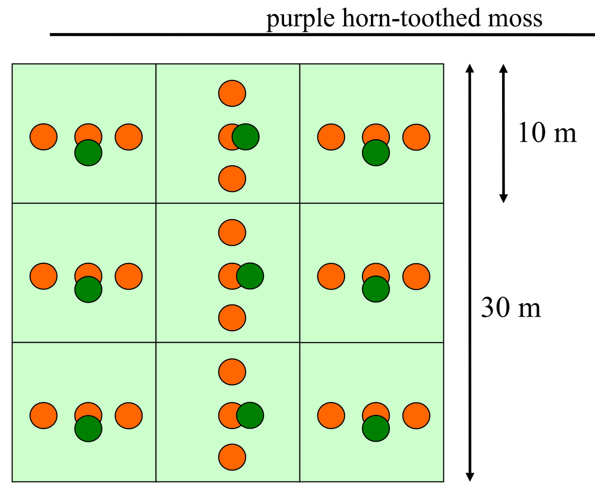


Fig. 3. Field sampling design

Vegetation cover was obtained from digital photographs of surface which were taken from approximately 1.5 m height. Excess green index (EGI, Woebbecke et al., 1995) was used to distinguish green plant and other materials (Fig. 5).

$$EGI = 2G - (R + B)$$ R, G, and B are RGB digital number (0-255).

Vegetation indices (ρ indicates reflectance)

$$NDVI = \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RED}}$$

$$EVI = 2.5\frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + 6\rho_{RED} - 7.5\rho_{BLUE} + 1}$$

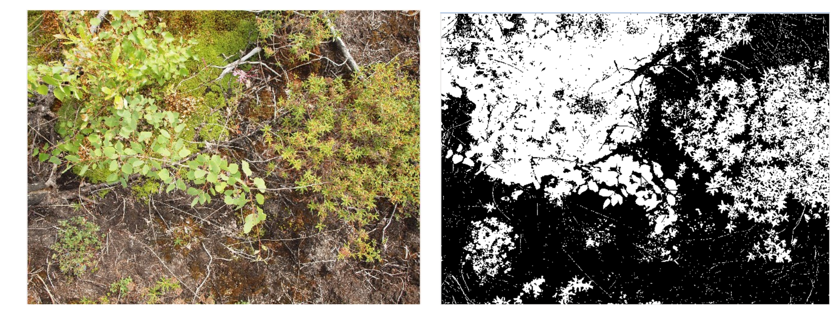
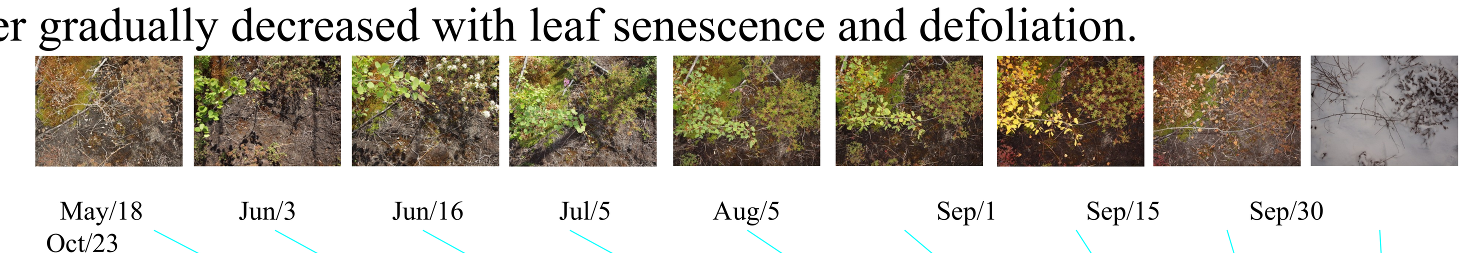


Fig. 5. An example photograph of the surface and its EGI distribution.

RESULTS & DISCUSSION

■ Vegetation cover based on photographs (Fig. 6)

As leaves of deciduous trees emerge, vegetation cover increased, and reached to the maximum around DOY (day of year) 200. Subsequently, vegetation cover gradually decreased with leaf senescence and defoliation.



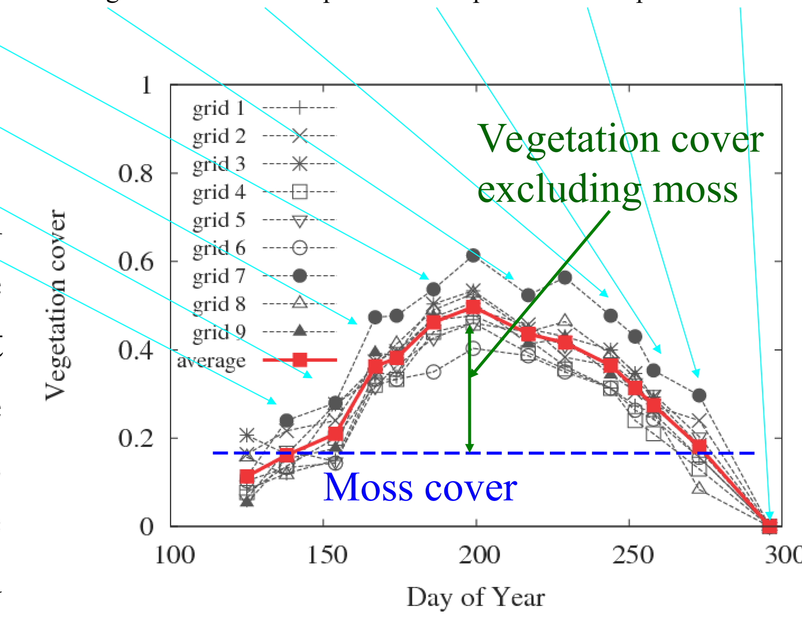


Fig. 6. Seasonal variation of vegetation cover at the six-year site

■ Transmitted PAR (Fig. 7)

Fraction of PAR_{tr} decreased with increasing vegetation cover. The minimum fraction of PAR_{tr} was about 0.65. Data surrounded with blue circles were collected in sunny days when the measurements at the surface were affected by shadow of burned black spruce. These data were discarded in the following analysis.

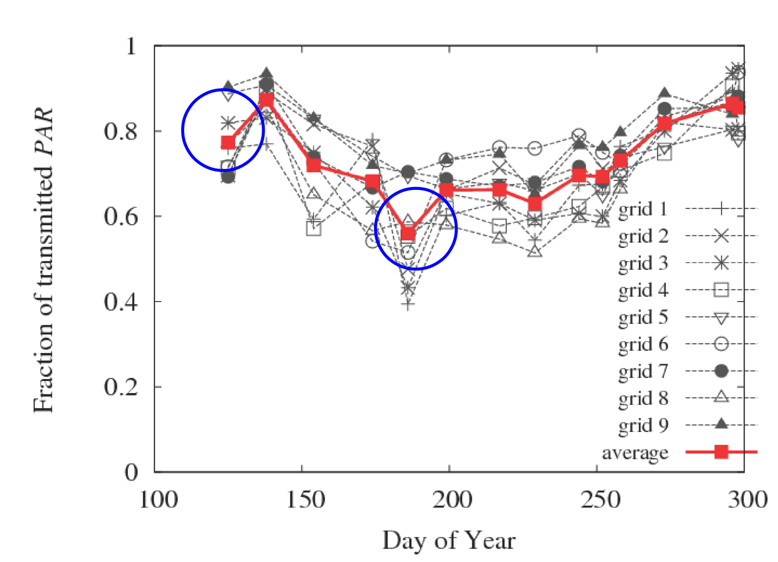


Fig. 7. Seasonal variation of fraction of PAR_{tr} at the six-year site

■ NDVI (Fig. 8)

NDVI also showed a seasonal variation reflecting that of vegetation cover.

■ LAI (Fig. 9)

LAI reached to its maximum around DOY 160, and did not change during summer. The beginning of decrease in LAI corresponded to the beginning of defoliation.

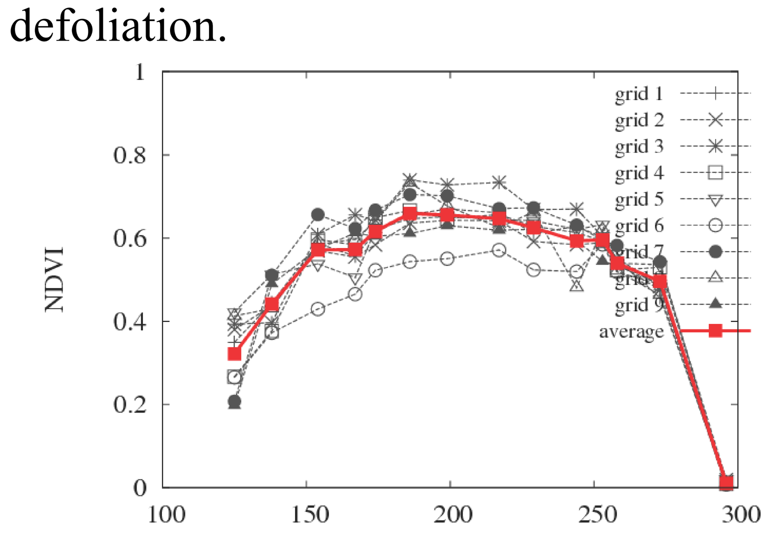


Fig. 8. Seasonal variation of NDVI at the six-year site

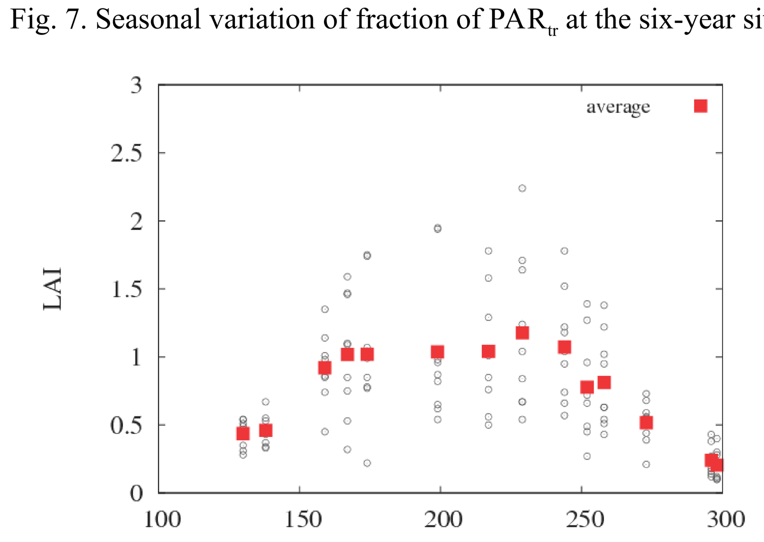


Fig. 9. Seasonal variation of LAI at the six-year site

■ FAPAR

PAR_{tr} observed in this study does not consider PAR absorption by mosses. Hence, PAR_{tr} was compared to vegetation cover excluding moss cover, and the relationship was extrapolated to the whole vegetation (Fig. 10). It is assumed that there is no moss cover at the one-year site.

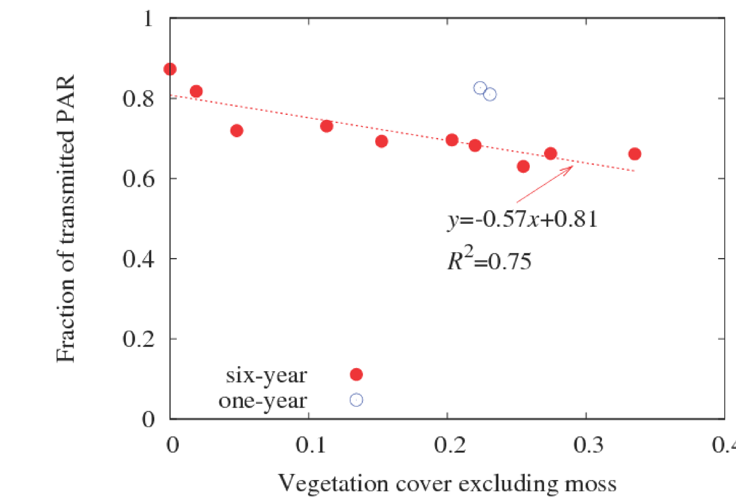


Fig. 10. Relationship between fraction of PAR_{tr} and vegetation cover excluding moss

The maximum FAPAR at the one-year and six-year sites were 0.16 and 0.38, respectively (Fig. 11). By considering the PAR absorption of moss, FAPAR increased by 0.1. MODIS FAPAR (MCD15A2) are overestimated compared to in situ data.

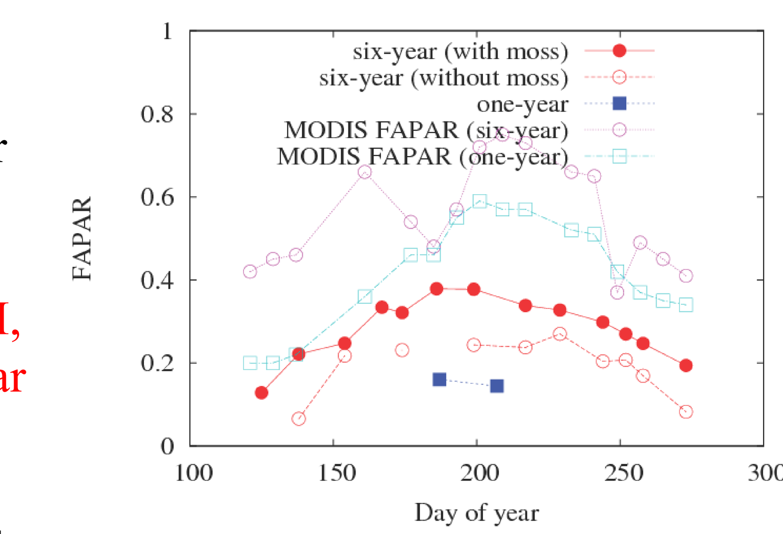


Fig. 11. Seasonal variation of FAPAR

For the six-year site, FAPAR has a linear relationship with NDVI (Fig. 12). Data for one-year site deviated from the relationship for the six-year site.

When FAPAR is plotted against EVI, FAPAR at both six-year and one-year site may be explained in a single relationship (Fig. 13). The same tendency for LAI was found by Rocha and Shaver (2009).

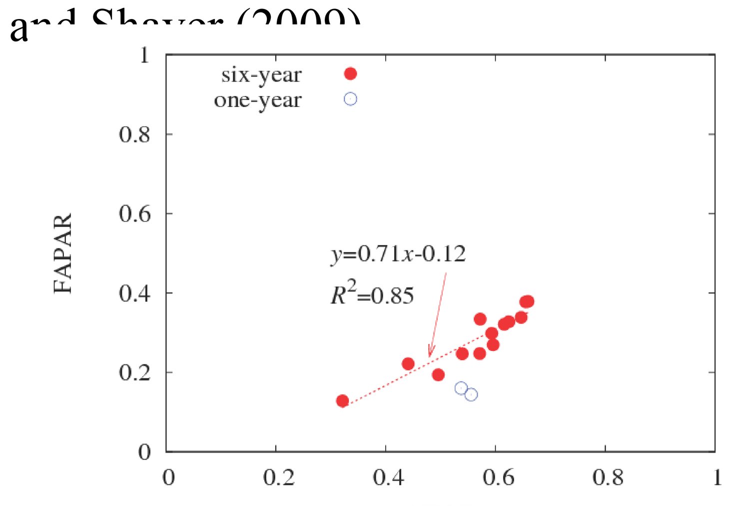


Fig. 12. Relationship between FAPAR and NDVI

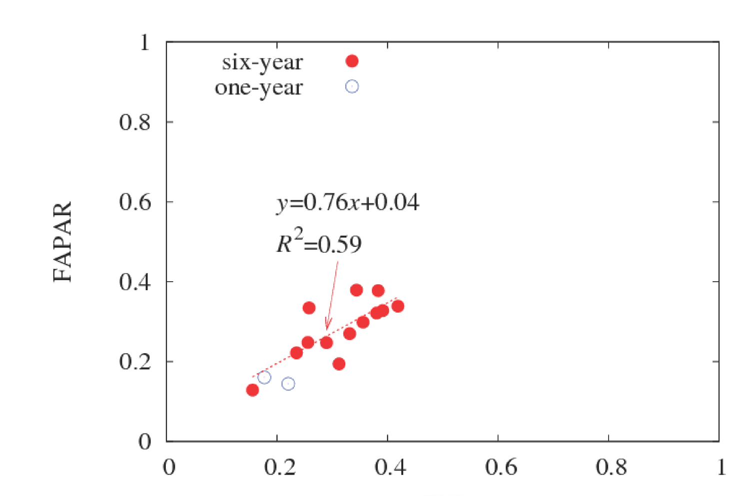


Fig. 13. Relationship between FAPAR and EVI

CONCLUDING REMARKS

- The ground truth data obtained in this study revealed that MODIS FAPAR was overestimated in the two burned forests.
- FAPAR has a linear relationship with NDVI, but the relationships were different for the two burned forests. On the other hand, FAPAR at the two burned forests may be expressed in a single relationship with EVI, implying that this single relationship can be applied to estimate FAPAR regardless of age after wildfire for the early stage of recovery.

ACKNOWLEDGEMENTS

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