Evaluation of the 2017 Kamaishi forest fire disturbance and recovery using NDVI based phenology

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1. INTRODUCTION

Forest fire can lead to changes in the hydrological process such as increased in sedimentation production to water bodies, loss of animal habitat, emission of carbon and the magnitude of these changes are due to several various factors including fire severity levels. Hence, it is important to assess the disturbance and recovery of the forest based on fire severity.

Satellite data which are open access and available at various resolution are used in forest fire studies to detect and monitor forest fire including estimating burn area. However, more studies are warranted to estimate fire severity at different spatial and temporal scales (Lentile *et al.*, 2006, Morgan *et al.*, 2014) and because forest fire events differ significantly between each event due to different ecosystems and climate. Thus, fire studies based locally is needed. Some existing studies utilise NDVI time series to monitor changes in vegetation due to disturbance. However, this study examines the disturbance and recovery based on fire severity defined by the damages found in crowns of trees.

2. STUDY AREA

The largest forest fire in Japan broke out in Kamaishi, Iwate Prefecture on 8 May 2017. The reported burnt area, 413 hectares, was larger than the total burnt area for the whole of Japan in 2016, 384 hectares as shown in Fig. 1.

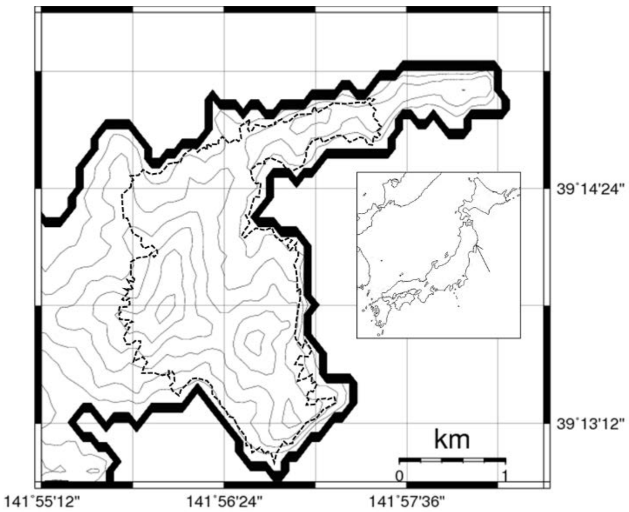


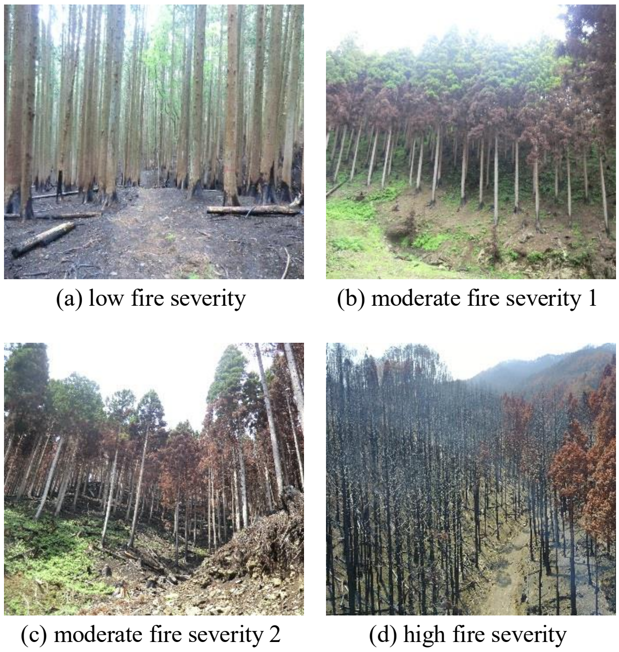
Fig. 1. Area affected by fire shown in dash linebased on information from Kamaishi Forestry Association (Touge *et al.*, 2018)

3. GROUND TRUTH

The fire severity levels were decided to correspond to the probability of tree mortality using (low, moderate, high) where each levels were based on percentage of scorch crown in the trees (Ryan, 1982) as shown in Table 1. In total 15 trees were used in this study, three trees from unburned areas (three needleleaf trees) and four trees for each fire severity levels (three needleleaf trees and a broadleaf tree). Examples of these fire severity are shown in Fig.2

Table 1 Classification of fire severity levels used based on the probability of tree mortality (Ryan, 1982)

Fire severity	Percentage of scorch crown height
Low	Less than 30 %
Moderate	More than 30 % but less than 80 %
High	More than 80 %



(a) low fire severity (b) moderate fire severity 1

(c) moderate fire severity 2 (d) high fire severity

Fig. 2. Examples of fire severity observed

4. SATELLITE DATA

NDVI from Landsat Surface Reflectance-derived spectral index product for Landsat-8 (Vermote *et al.*, 2016) provided by the U.S Geological Survey which had undergone atmospheric correction were used in this study. These images from January to December 2017 were cloud-free and snow free and the NDVI values were then extracted for the 15 trees used in this study.

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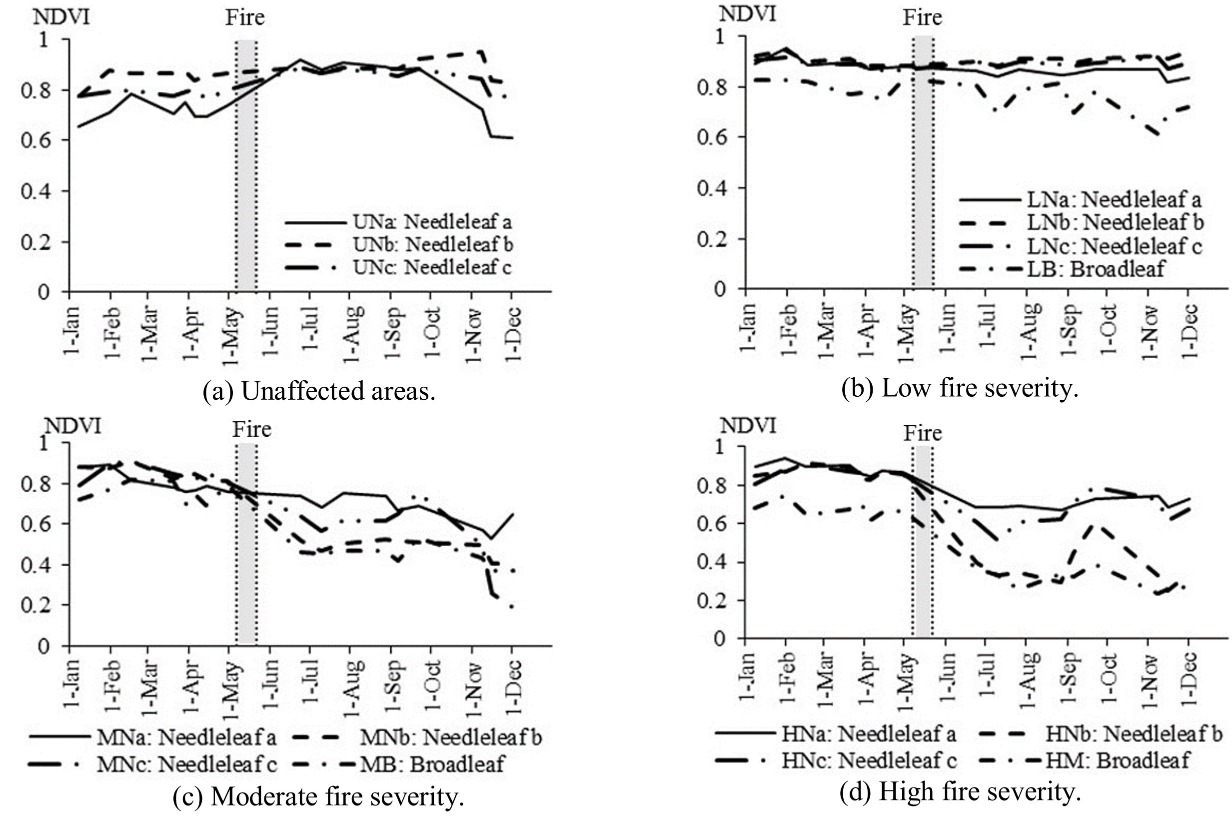
5. RESULTS



(a) Unaffected areas.

(b) Low fire severity.

(c) Moderate fire severity.

(d) High fire severity.

Fig.3. NDVI based phenology for trees in different fire severity levels.

As expected, NDVI trend for unaffected trees increase after fire because all trees grow without fire disturbance (Fig.3(a)) and all trees at high fire severity areas showed the most decreasing NDVI values (Fig.3(d)). NDVI trend for all needleleaf trees were higher than broadleaf trees regardless of the fire severity suggesting the difference canopy characteristic between both tree types may affect the fire severity detected by satellite Fig.3(b)-(d).

The decreasing trend for LNa and LB was due to LNa having more than 50% charred on its stem-bark suggesting damage on stem-bark should be considered as a measurement of fire severity as well while LB was due to its location adjacent to a high fire severity area which affected its NDVI values(Fig.3(b)). NDVI trends in Fig.3(c) follow the ascending percentage of scorch crown (MNa, MNc, MNb and MB) suggesting quantitative observation of the trees are needed to explain NDVI drop.

The subsequent NDVI increase in Fig.3(c)-(d) was mainly due to the growth of tree and grass respectively that can be captured by Landsat-8 as the crown of these trees were destroyed but the trend from September and October onward for Fig.3(c)-(d) respectively are difficult to interpret without further field investigation.

6. CONCLUSIONS

All results showed decreasing trend in NDVI as the fire severity increased. The biggest drop in NDVI were observed in trees in high severity while minimal drop for trees in low fire severity. This indicate NDVI is capable in evaluating forest fire disturbance and recovery. However, field investigation several months after fire is warranted to explain some NDVI trends to enhance understanding of forest fire recovery.

7. ACKNOWLEDGEMENTS

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8. REFERENCES

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