Abstract

Forest disturbance and recovery has been regarded as a primary mechanism for transferring carbon between land surface and the atmosphere, and thus plays a key role in the terrestrial carbon balance. Identification and monitoring of forest disturbances is an important global and regional application, where updated information about where and when disturbances have occurred, and the area affected and recovered, is crucial.

Traditional forest investigation appears comparatively time-consuming, costly, but inefficient, and difficult to achieve full-cover and real-time monitoring. It is believed that, at regional and greater scales, the only feasible and effective means to monitor forest disturbance and recovery continuously and regularly is remote sensing.

Fire is a common disturbance regime, especially in boreal forests. It is a complex issue, both ecologically and socially, affecting the forest ecological process either as a positive agent of renewal or a highly destructive force. Fire effects and post-fire forest dynamics have been widely studied. A wide range of such studies are based on field forest investigation alone, while many researchers and managers are combining field survey data with remote sensing imagery to monitor post-fire forest patterns relying on their long temporal coverage, sufficient spatial and spectral resolutions which permit capture of most forest features.

The Greater Hinggan Mountain area, located in the northeast China, is rich in forest resources while suffers from a high incidence of forest fires simultaneously. Among all the fires in this area, the most noteworthy one is the “5.6 Fire” that occurred on May 6 1987 and developed to be the most serious forest fire for P. R. China. Aiming at this fire, this thesis proposes to detect the burned forest area, and monitor the post-fire forest recovery using field survey records and multi-source optical and SAR data. Particular emphasis has been laid on the effects of different restoration strategies for post-fire forest regeneration and vegetation recovery.

First of all, the fire scar and burned forest area was extracted and mapped using Landsat TM imagery by multiple methods. During the mapping, the fire perimeter, as well as rivers, roads and building areas were first delineated and masked, and then four indices were calculated. For comparison, threshold segmentation using the reflectance of original six multispectral bands was performed, in addition to a MLC-based supervised classification of all features and forest area alone. Their accuracies were also evaluated and analyzed. Compared to the traditional methods used to report official statistics on burned areas, the remote sensing-based extraction is less labour- and time-consuming, and more objective and efficient.

Following this fire, the local forestry bureaus have taken a series of measures for the forest recovery. Typically three different restoration treatments, namely natural regeneration (NR), artificial regeneration (AR), and artificial promotion (AP), are adopted for the forest regeneration in the burned area. In order to elucidate the effects of the three treatments, a field survey was conducted to collect the attribute data, specifically species composition, structural parameters, and LAI, which were

analyzed through ANOVA and a post-hoc test. Results suggest AR to be adopted in post-fire recovery if the goal is timber production, while NR should be selected when focusing on canopy vertical density and species richness. These findings can be used for reference in local forest management.

Considering the limitations of field forest survey, multi-source remote sensing data were also employed to monitor the forest recovery trajectories after the “5.6 Fire”. These data include the Landsat TM/ETM+ imagery, MODIS Land Cover Type and Vegetation Indices products, and ALOS PALSAR FBD data.

With Landsat TM/ETM+ records, totally 12 scenes covering the period of 1987-2011 were used for the post-fire forest recovery monitoring. In addition to the commonly used vegetation indices, a more effective index of DI was examined and evaluated. Combining with the field survey data analysis, the availability of different remote sensing indices and applicability of the three restoration treatments were evaluated and compared. Results indicated that the forest under NR achieved a totally different recovery process with those under the other two treatments.

Due to the unique characteristics of MODIS sensor, the well-developed MODIS Land Cover Type products were exploited to monitor the temporal and spatial dynamics of forest coverage. It centered on the hypothesis that the annual variability in coverage of different types of forest during 2001-2012 can be detected. Results suggested that the area of “Mixed forest” gradually increased from 46.34% in 2001 to 80.50% in 2012, while that of “Cropland/Natural vegetation mosaic” decreased from 30.46% to 5.94% in this period.

In addition to the optical images, ALOS PALSAR data covering the period 2007-2010 were also applied to detect the post-fire dynamics. The backscattering intensity in HH and HV polarization and the derived radar indices of RRVI and RNDVI were examined and evaluated. Results showed that, compared to the other two treatments, forests under NR presented a different recovery trajectory. They were consistent with those achieved by LAI and DI which together demonstrated the reliability of the forest recovery trajectory monitoring.

For more direct and targeted evaluation and comparison among the performances of different sensors, the linear statistical modeling was applied using field measured LAI and remote sensing indices from ALOS AVNIR-2, Landsat-5 TM and MODIS NBAR, ALOS PALSAR data. The gap between the spatial resolution of Landsat-5 TM and MODIS NBAR data with the field plot size can account for the reduced accuracy. Nonetheless, the data with higher spatial resolution and retrieval accuracy usually have lower efficiency in spatial and temporal coverage, and require higher acquisition costs. Thus in specific applications, the actual accuracy needs should be carefully considered to achieve a cost-efficient result.

Finally, the knowledge gained throughout this thesis is summarized, and limitations and deficiencies existed within this exercise has also been identified and commented, based on which, the improvements with regard to future studies are discussed and recommended.