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Қапшағай СЭС плотинасы, Іле өзенінде мекендейтін сазан, көксерке, ақмарқа дараларының асқазан-ішек жолдары, бауыры, желбезектері, жыныс бездері мүшелеріне патоморфологиялық зерттеулер жүргізілді. Барлық зерттелген даралардан жоғары дәрежеде бауыр және желбезектерінде пайда болған, компенсаторлы-бейімделу сипатында морфологиялық өзгергіштіктер айқындалған. Олар желбезек жапырақшаларының эпителийінде таяқша және шырышты клеткалар санының көбеюімен, эпителий жапырақшаларында шырышты клеткалардың пайда болуымен, бауырдың периваскулярлы кеңістіктеріндеісіктік пайда болуымен, бауырдың периваскулярлы кеңістіктеріндегі моноцитарлы және лимфоцитарлы инфильтрациялар және ішек эпителийіндегі лимфоцитарлы инфильтрациялармен көрінді. Сазан дараларының бауырында, желбезектерінде, аналық бездерінде деструктивті сипаттағы морфологиялық өзгерістер белгіленді. Олар гемостаз пайда болған жекеленген желбезек ламеллаларының тамыр қабаттары, жалпы қабыну процестерінде және бауыр ұлпаларының некротикалық өзгерістерінде, қан тамырларының бұзылуынан (қан құйылу, ісіктер, бауыр артерияларындағы тромбоздар), сондай-ақ бауырдың өт бөлу жолдарындағы бауыр строماларындағы дәнекер ұлпасының ұлғаюынан, жыныс бездеріндегі ооциттердің дегенеративті өзгерулері де струкциясында байқалған. Сазан дараларынан зерттеліп, анықталған патоморфологиялық өзгерістер, яғни сазан балығы бентофаг ретінде ластанған заттардың әсеріне жоғары дәрежеде ұшырайды, нәтижесінде мүшелердің патологиялық өзгерістерге алып келеді деп түсіндіріледі.

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The pathomorphological study of the gastro-intestinal tract, liver, gills, sexual glands in the individuals of asp, pike perch, sazan, from the Ile river in the area of the dam Kapchagay Hydroelectric power station was held. The morphological changes of compensatory and adaptive nature, expressed to a greater extent in the liver and gills, were identified at all investigated species. It was expressed in the increase of the number of mucous and rodlet cells in the epithelium of gillnet petals, the emergence of mucous cells in the epithelium of lamellae, oedema in the epithelium of gillnet petals and lamellae, oedema in the spaces around the blood vessels of liver, the infiltration of liver' perivascular spaces by monocytes and lymphocytes, lymphocytic infiltration of the intestinal epithelium. The destructive morphological alterations were marked in the liver, gills, ovaries of sazan. These were expressed in the destruction of the vascular layer of the individual gill lamellae with the phenomena of hemostasis, extensive inflammatory and necrotic changes in the liver tissue, alterations of the vascular bed (hemorrhage, edema, hepatic artery thrombosis) and bile ducts diseases of the liver, expansion of the connective tissue of liver stroma, degenerative changes of eggs in the ovaries. Expressed pathomorphological changes in the studied carp species can be explained by the fact that carp, as fish benthos fed, to a greater extent exposed to the pollutants that lead to pathological changes in the organs.

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RAPID EVALUATION OF FOREST DAMAGED BY TYPHOON USING MULTISPECTRAL SATELLITE DATA – CASE STUDY IN HOKKAIDO JAPAN

Abstract *Typhoon SONGDA (2004.09) caused serious damage to the forest of Hokkaido. Data from Terra/ASTER were used to extract fallen trees in the south-western inland and coastal area of central Hokkaido. We used vegetation indices in conjunction with maximum likelihood classification (MLC) to map the fallen tree pixels. The extraction of fallen tree clusters resulting from intense winds has been successfully demonstrated using Terra/ASTER satellite data.*

Keywords *typhoon SONGDA ・fallen trees ・satellite monitoring・Terra /ASTER・Hokkaido*

Introduction

Japan is an archipelago frequently affected by typhoons. In September 8th 2004 it experienced Typhoon SONGDA that was considered one of the destructive typhoons to hit Hokkaido, the northernmost island. The effect was devastating and caused extensive damage in agriculture, forestry and other infrastructure (Buhe et al., 2005). Forest damage due to strong wind such as fallen trees was evident in the areas affected. However, evaluation on the extent of the devastation was very difficult because of inaccessibility of the area affected.

Quick assessment of distribution and estimation of the degree of damage of forests after typhoons are important for government institutions and non-profit organizations involved in the planning of forest and wildlife management. This study envisions for a method that can evaluate typhoon damage rapidly and easily. Remote sensing technology with its unique synoptic coverage has a unique potential in evaluating the forest damage in a large area (Ekstrand, 1994, 1996). Satellite images can offer sources of information to rapidly evaluate the spatial extent and damage of affected forests. In previous research work concerning fallen trees mapping using satellite, Landsat and SPOT has been in common use (e.g., Mukai and Hasegawa 2000; Clandillon et al. 2003), and methods for extraction such as classification, visual approach, multitemporal approach have been proposed. Recently it has been reported research work using SAR interferometry techniques (e.g., Dwyer et al. 2000), SAR and SPOT with combined (Yesou et al. 2003). However, these are not always better ways in cost, resolution, covered area and operability in which it was all considered. The research of the windfall trees extraction using ASTER launched in 1999 is very little, though it is predominant in these points.

The aim of this study is to evaluate the forest damage by the typhoon SONGDA in Hokkaido, Japan rapidly and easily using ASTER. Moreover, we intend to clarify the spectral characteristics of windfall trees, and examine the effectiveness of the index using Short Wave Infrared. These will prove the potential use of remote sensing technology for efficient evaluation of future typhoon damage in forested areas.

Methods

*Two study sites including the forests that have been damaged seriously by the typhoon, Lake Shikotsuko area (center point: N42° 45' 37.44», E141° 29' 30.58») and Nopporo forest park area (center point: N43° 02'38.74», E141° 31'22.55»), were set (***Fig. 1**). Lake Shikotsuko area is 99,473 ha located in coastal area of central Hokkaido, dominated by coniferous and broad-leaved mixed forest including planted, and Nopporo forest park area is 2,053 ha in inland of south-western Hokkaido, mostly covered with natural forest of deciduous and coniferous trees.

In order to evaluate the forest windfall damage by the typhoon SONGDA, we performed a field survey at line sensors and 64-points using Global Positioning System (GPS) and took aerial photographs (September 15th 2004). We further investigated forest damage in a wide area using remote sensing techniques. The data was analyzed by first extracting the pixels associated with fallen trees. ATCOR software (version 3) method was used for the correction of the atmospheric effect about path radiance, adjacency radiation and terrain radiation reflected to the pixel. The atmospheric conditions (water vapor content, aerosol type, and visibility) for a scene were estimated by target pixel of the image using SPECTRA module of ATCOR3. The reflectance spectrum of a target in the scene can then be viewed as a function of the selected parameters (Hoshino et al., 2009).

Figure 1. Study sites ((A): Nopporo forest park area, (B): Lake Shikotsuko area)

Data used were from Terra/ASTER original Level 1B Visible-Near Infrared/Short Wave Infrared Thermal Infrared (VNIR/SWIR/TIR) Data (Before Typhoon: 10:25 AM, October 17, 2001, and After Typhoon: 10:25 AM, September 23, 2004, Path-108/Row-886, N42°50'15.62», E141° 2'15.96», provided by the ©ERSDAC, Japan). The preprocessing of ASTER data included resampling of the 3-different layers having different resolution i.e., VNIR (15 m), SWIR (30 m) and TIR (90 m) data to a common spatial resolution of 15 m; and statistical evaluation of correlation coefficients between different bands was made.

First, the supervised classification was carried out using maximum likelihood method with field survey data and ASTER image, and accuracy was evaluated with error matrix of forest damage area in study sites. Next, Normalized Difference Vegetation Index (NDVI, calculated by equation (1)), Leaf Area Index (LAI, calculated by equation (2), Chen, et al., 1992) and Vegetation Leaf Water Index (VLWI, calculated by equation (3), Buheaosier et al., 2004) were calculated in this study as the indices expressing the vigor of vegetation. Since satellite can measure the amount of sunlight reflected in the red and NIR spectrum, NDVI can be computed to measure greenness or plant health that can be displayed as an image. NDVI was calculated using an equation as described by Asrar and Baret (Asrar, et al., 1984; Baret, et al., 1991).

$$NDVI = \frac{NIR - RED}{NIR + RED} \qquad 1$$

$$LAI = -\frac{1}{a_2} \times \ln\left(\frac{a_0 - NDVI}{a_1}\right) \qquad 2$$

$$VLWI = K_0 + \left[\frac{NIR - SWIR}{NIR + SWIR}\right] \qquad 3$$

Where, RED, NIR and SWIR are reflectance in visible Red, Near Infrared and Short Wave Infrared bands and K_0 is an adjusting factor for the influence of the background soil reflectance (where, input K_0= 0.50 at half vegetated area, and input K_0= 0.0 at 100% vegetation covered area (Buheaosier, et al., 2004). In this case, we input K_0 = 0.25 at Lake Shikotsuko site fallen tree area); a_0, a_1 and a_2 is parameters of vegetation with varied vegetation (or soil) types. For example, $a_0=0.82$, $a_1=0.78$ and $a_2=0.60$ is cotton; or $a_0=0.68$, $a_1=0.50$ and $a_2=0.55$ is corn (after Asrar et al. 1984 and Baret et al., 1991). In this study, $a_0=0.98$, $a_1=0.85$ with healthy forest and , $a_0=0.41$, $a_1=0.38$ with fallen trees.

Results and Discussion

Fig. 2(A) *and* **(B)** *show the output forest damage area map of test areas, Lake Shikotsuko site and Nopporo forest park site, respectively resulted from supervised classification.* **Table 1** *shows the supervised classification error matrix of forest damage area. As fallen trees lost the characteristics of healthy trees, they resemble the barren soils pixel etc. and are misclassified. In this case, most of the trees suffered from damage of windfall are Sakhalin*

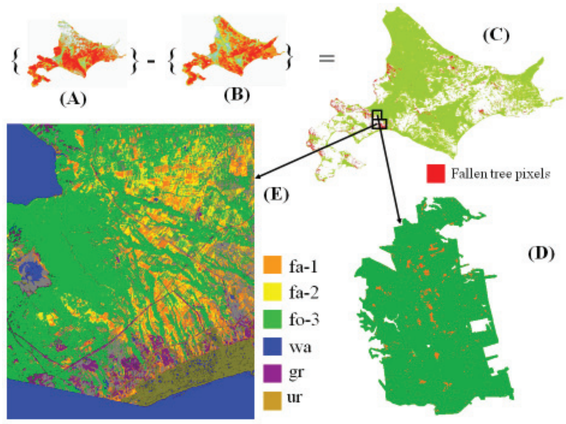

Figure 2. (color) (A) is output forest damage map of test area of Nopporo forest park;
(B) is output forest damage map of test area of forest near Lake Shikotsuko (in Fig. 1, fall (65%) and (90%) – shows fallen tree covered 65% and 90% area; for-shows healthy forest area; wat-shows water bodies; bars-shows barren soil area; urb-shows urban area; mot-mountain area)

*fir (Abies sachaliensis), Sakhalin spruce (Picea glehnii) and Ezo spruce (P. jezoensis) that are both artificial plantation areas while some are natural forests. Comparison of fallen trees and healthy forest based on the reflectance of fallen trees in both sites shows suite of higher value in ASTER band-2 (red chlorophyll absorption) and shows the suite lower value in the ASTER band-3 (NIR: chlorophyll reflection), that means the fallen tree has lost the function as a healthy tree (***Fig. 3***). The fallen tree can be specified by comparison of the value of NDVI calculated from the satellite data before and after a typhoon per pixel. The NDVI values of leaves before and after the typhoon in same pixels shown on* **Fig. 4**. *In northern Japan, leaves starts to wither in September causing low NDVI values and further becomes lower in October. However,* **Fig. 4** *showed that October NDVI value was higher than that of September thus we consider the pixels in September representing the fallen trees.*

Taking into consideration that no satellite image is available before the typhoon, determination of fallen tree can still be performed contextually by comparing NDVI of damaged and healthy forests in post typhoon image provided the tree type and other environmental conditions are alike. Of the nine points investigated in this study in both sites, NDVI of healthy forests have a mean of 0.778 whereas fallen trees have 0.403 on 15-days after the typhoon (Fig. 5). Similarly the average value of VLWI of healthy forest is 0.797, but VLWI of the fallen trees has decreased to 0.537 (**Fig. 5**). *An important index for extraction of the fallen tree is the LAI since these trees have very small LAI compared*

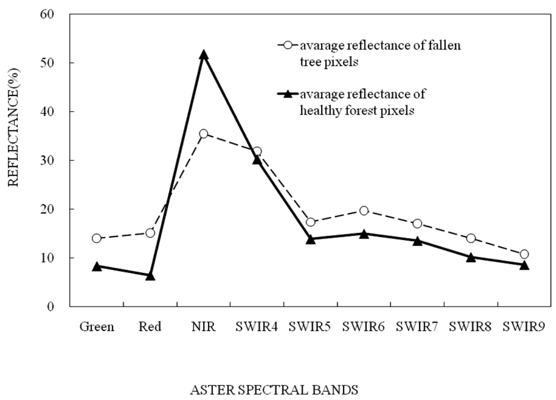

Figure 3. Comparison of the spectral reflectance of fallen tree pixels and forest pixels using ASTER VNIR/SWIR data after the typhoon (Sep. 23, 2004)

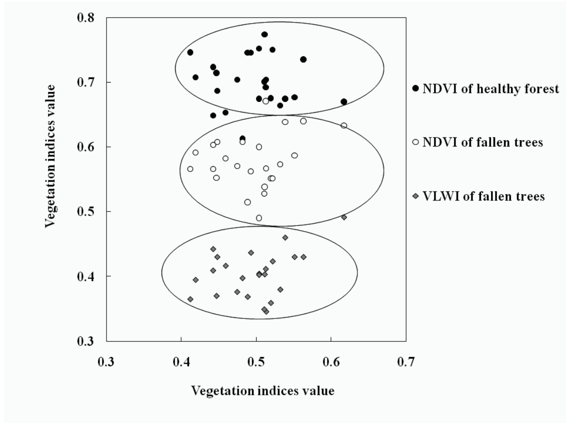

Figure 4. Comparison of the NDVI value of forest before and after the typhoon using ASTER data (before typhoon: Oct. 17, 2001; after typhoon: Sep. 23, 2004, in the same pixel)

*to a healthy forest. Furthermore, it becomes smaller as time is passed. 15-days after the typhoon, the value of 0.8<LAI=<1.5 shows fallen trees pixel. Average LAI value of forest is 2.0 while average LAI value of fallen trees is 1.0 in all of the monitored area, and this result is confirmed by field study (***Fig. 6 (A, B)**.

These decreasing of values in indices are because fallen trees have been losing the water content of their leaves gradually and green leaf photosynthesis function of chlorophyll of the fallen trees has dropped, in addition to these, the tree trunk has revealed by windfall and that the spectral reflection characteristic

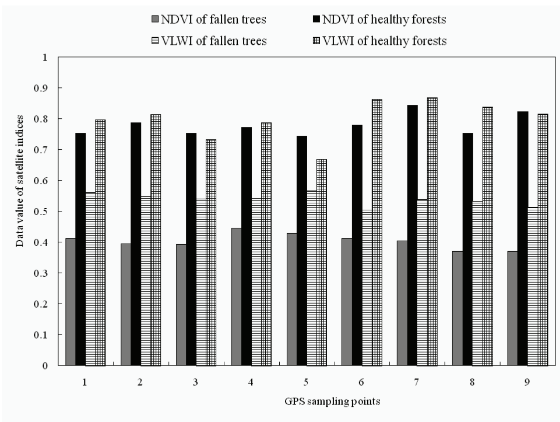

Figure 5. Comparison of the NDVI (and VLWI) value of a healthy forest and the fallen trees at investigated points using ASTER data after the typhoon (Sep. 23, 2004)

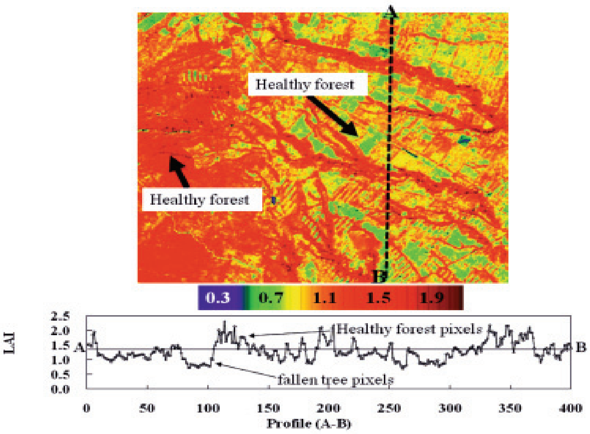

Figure 6. *LAI map of fallen trees and forest using ASTER data after the typhoon (Sep. 23, 2004). The value of 0.8<LAI=<1.5 is fallen trees pixel and is shown in black color*

changes seems to also greatly contribute. In this research, we succeeded in evaluation of the forest damage by the typhoon based on satellite data (NDVI, VLWI and LAI) of pre and post typhoon.

Table 1

Supervised classification error matrix of forest damage area calculated by maximum likelihood classification

	Reference Class	1	2	3	4	5	6	7	8	Total	User's Accuracy
	Map Class	Fall (65%)	Lake	Forest	Barren soil	Mountain	Urban	Sea	Fall (90%)	Pixels	(%)
Fall (65%)	1	1466	0	14	22	5	1	0	402	1910	76.8
Lake	2	0	15033	0	0	0	0	8	0	15041	99.9
Forest	3	1	0	1876	3	0	0	0	0	1880	99.8
Barren soil	4	23	0	8	473	0	0	0	0	504	93.8
Mountain	5	19	0	0	0	3937	371	0	11	4338	90.8
Urban	6	8	0	0	15	471	2592	0	1	3087	84
Sea	7	0	0	0	0	0	0	10593	0	10593	100
Fall (90%)	8	15	0	0	0	0	0	0	196	211	92.9
Total	Pixels	1532	15033	1898	513	4413	2964	10601	610	37564	□
Producer's accuracy	□(%)	95.7	100	98.8	92.2	89.2	87.4	99.9	32.1	□	□

Present study confirms that remote sensing using ASTER is an effective method to evaluate forest fallen tree damage by typhoon and can be applied to wide area as well. This method can be utilized to provide forest and wildlife management authorities on the distribution and extent of forest damage at least 15 days after devastating typhoons.

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Тайфун SONGDA (2004.09) нанес серьезный ущерб лесу на Хоккайдо. Данные от Terra/ASTER были использованы для оценки упавших деревьев на юго-западе внутренних и прибрежных районов центрального Хоккайдо.

Мы использовали вегетационный индекс в сочетании с максимальной вероятностью классификации (MLC) для картирования пикселей упавших деревьев. Извлечение кластеров упавших деревьев в результате интенсивных ветров было успешно продемонстрировано с использованием спутниковых данных Terra / ASTER.

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SONGDA тайфуны Хоккайдо аралының орман алқаптарына зор нұсқан келтірген. Terra/ASTER спутнигінен алынған мағлұматтарды пайдалана отырып, орталық Хоккайдо аралының оңтүстік батыс және жағалық аймақтарында нұқсан келген орман алқаптарының қазіргі жағдайы сипатталынған. Жұмыс барысында нұқсан келген орман алқаптарының картасын жасау мақсатында MLC жіктеу әдісі, сонымен қатар вегетациалық индекс әдістері пайдаланылған. Қатты желдің әсерінен нұқсан келген орман алқаптарын, зақымдану дәрежесіне байланысты жіктеу жұмысы Terra/ASTER спутниктерінен алынған мағлұматтарға сүйене отырып жүргізілген.