so on. To overcome the above problems, required conditions of forest registration for the next generation are discussed in this paper. We need various information in forest planning, not only data of forest registration but also data of other organizations. By using spatial analysis function of GIS, we analyze various types of data such as, polygon data of forest compartment, raster data of remote sensing, point data of GPS, DEM and DSM by aircraft laser profiler. Consequently, it is recommended to keep forest data as thematic map in GIS. Present data of forest registration should be segmentalised into some thematic maps. Minimum basic data in forest GIS would be thematic map of forest physiognomy. Historical data of each forest stand would be link with forest GIS by hyperlink. Fundamental scheme of forest registration for the next generation is GIS-based structure which means that we use forest GIS as a tool of spatial analysis, not as a database.

Additional keywords: forest registration, database, forest GIS, thematic map, spatial analysis

**ORAL SESSION**

**Monitoring of Peat Swamp Forest using PALSAR Data: A Trial of Double Bounce Correction**

Yoshio **Awana (Gifu University, Japan)**

Reduction of Deforestation and Forest Degradation (REDD) is an international political issue, since about 20% of human-induced carbon emission is estimated to be caused by deforestation in the tropics. Monitoring deforestation is an important activity, since it provides basic information in REDD. Satellite remote sensing makes the monitoring possible in a large area. However, clouds disturb clear forest observation by optical sensors in tropics. Synthetic Aperture Radar (SAR) can observe the earth surface under overcasted condition from the space. Therefore SAR would provide valuable information about forest. Huge peat land forest area has been developed for rice production since latter 1990s in Central Kalimantan, Indonesia. The project caused the greatest impacts on deforestation and forest degradation in that area. There are numerous forests under declining by forest fires and reclamation still now. We aim at monitoring the peat swamp forest using ALOS/PALSAR data to demonstrate possibility of monitoring forest area by reducing the effects of double bounce on PALSAR data in open swamp forests and fire scars. Our study reviled that degradation and fragmentation continues, however, water levels in the swamp area suffered forest monitoring using PALSAR data. Although we succeeded in reducing effects of double bounce and monitoring forest changes, stand biomass was not estimated accurately. However, it would be possible to classify vegetation into about 5 classes according to biomass and to monitor deforestation.

Additional keywords: forest fire, mega rice project, backscattering coefficient

**Estimation of LAI and Related Metrics using Small-footprint Airborne LiDAR without a Digital Terrain Model**

Kazukiyo **Yamamoto, Naoto Kondo (Nagoya University/CREST, Japan), Yoshiyuki Takaichi, Masashi Tsuzuki and Naoki Murate (Nakanihon Air Service Co., Ltd., Japan)**

The relationship between canopy structure and temporal and spatial distribution of incident understory light has been used with particular interest for evaluating the effects of silvicultural prescriptions on the survival, pattern, and diversity of understory plants and trees. Although numerous ground-based optical tools and techniques have been developed to measure various attributes of forest canopy structure and understory light environment, it is difficult to measure these attributes around the vast forested area using the ground-based methods. In our previous studies, we presented a new methodology that did not require a digital terrain model (DTM) to estimate mean tree height using small-footprint airborne LiDAR data. In this study, we applied this method to estimate the leaf area index (LAI: m²/m²) and the related metrics concerning the light environment within the forest, i.e. canopy openness (CO: %) and sky factor (SF: %). Using the hemispherical images taken at 161 points (hereafter called for “Photo Points”) within the hinoki cypress plantations and the LiDAR data, we investigated the relationship between the metrics calculated from hemispherical image (LAI, CO and SF) and the laser interception ratio (LIR: %) calculated from LiDAR data using the method presented in our previous study. In addition, because the LiDAR-drivened metrics would be more or less scale-dependent as suggested by previous researchers, we thus compared the LIR calculated from the range R (5 m to 60 m in 5 m intervals) in diameters centered on a Photo Point for investigating the optimal scale to estimate the LAI, CO and SF from LiDAR data.

Additional keywords: airborne LiDAR, LAI, canopy openness, sky factor, DTM

**Estimating Total Biomass Carbon Stock and Carbon Absorption in Manmade Coniferous Forest Stands by Combining Low Density LiDAR and Yield Table**

Eiji **Kodani (Tohoku Research Center, Forestry and Forest Products Research Institute, Japan) , Tomohiro Nishizono (Forestry and Forest Products Research Institute, Japan) and Yoshiio **Awana (Gifu University, Japan)**

We developed a method to estimate total biomass carbon stock and carbon absorption in manmade coniferous forest stands by combining low-density LiDAR and yield table. We established a transect 20-km long and 100-m wide that traverses the western part of Shikoku Island, Japan. Airborne LiDAR data for the transect were obtained in September 2002 by the Asahi-koyo Corporation. We set plots within the transect. The plots included non-forest areas and small to large forest stands of manmade coniferous forest of Sugi (Cryptomeria japonica) and Hinoki (Chamaecyparis obtusa), (n = 24). A linear regression analysis was performed between the LiDAR indices and the total biomass carbon stock. The total biomass carbon stock had the strongest relationship with the index of the last pulse average ($r^2 = 0.89, p = 0.000$). We estimated the total biomass carbon stock using the airborne LiDAR data and the regression line. Forest stand carbon absorption was estimated using a yield table (empirical growth model) with input variables of stand age from forest GIS, site index, and stand volume from the low-density LiDAR.
Analysis of High School Students’ Perceptions of the Functions Served by Forests
Mari KAWASE (Kyoto University, Japan)
Understanding young people’s perceptions of the functions of forests is important in developing forest-management strategies. This study investigated factors associated with high school students’ perceptions of the functions of forests, particularly as related to their knowledge of forests and experience of visiting forests. Questionnaires were distributed to first-year students at a public high school in Kobe, Japan, in 2009, yielding 285 responses (response rate of 97.6%). Nine functions (e.g., carbon storage, timber production) were suggested in the questions. The students’ perceptions of forests were compared among three types of forest described by the terms “forest,” “artificial forest,” and “natural forest.” The results allowed for a clear understanding of the student’s perceptions of forests, revealing the following:
1. The function of carbon storage was highly rated in all types of forest.
2. Knowledge of forest management could be divided into three categories: management by people, harm caused by nature, and substitutes for wood products.
3. Experience visiting forests was determined largely by grade. Students visited forests most when they were in elementary school. However, whether the students visited forests at present had no significant influence on their responses to the questionnaire.

Additional keywords: questionnaire, high school students, knowledge of forests, visit to forests, function of carbon storage, logit model

Forest and Human Development: Analysis of Socio-economic Factors Affecting Global Forest Area Changes
Tetsuya MICHINAKA and Motoe MIYAMOTO (Forestry and Forest Products Research Institute, Japan)
World forest area has been decreasing, but different countries witness different changes. In order to clarify the main socio-economic factors affecting changes in forest areas, cluster analysis is firstly undertaken to 206 countries by their levels of per capita GDP and rate of rural population, and three clusters are obtained, i.e., Cluster 1, consisting of 80 countries with high level of rate of rural population but low level of per capita GDP; Cluster 2, consisting of 87 countries with lower rate of rural population but higher per capita GDP; and Cluster 3, consisting of 39 countries with low rate of rural population but high per capita GDP. Secondly, panel data analysis is undertaken to these three clusters separately. The following six factors are considered in the model specification: life expectancy, adult literacy rate, gross national income per capita, total population, rate of rural population, and agriculture gross production value. Total population and Gross national income per capita are significant in all these clusters, but have different coefficients and signs. It is found that countries in Clusters 1 and 2 face pressure from population growth, while forest area will increase in countries in Cluster 3 if population increases. It also shows that increase in income will help to increase forest resources but in different scale. Forest area faces pressure when adult literacy rate increases in Cluster 1, but increases in adult literacy rate in Cluster 2 is good for increases in forest area. The rate of rural population is important for countries in Cluster 3 to maintain forest resources. It finds that in different levels of human development, humans have different relationships with forest resources.

Additional keywords: deforestation

Assessment of Forest Carbon Stocks in Cambodia
Nophea SASAKI (University of Hyogo, Japan), Kimsun CHHENG (Forestry Administration, Cambodia), Nobuya MIZOUE (Kyushu University, Japan), Dana KAO and Vathana KHUN (Forestry Administration, Cambodia)
While intensive discussions on REDD+ mechanism and its roles for multiple benefits have been going on, how carbon emission reductions can be achieved depending on how well we understand the current carbon stocks in the forests where REDD+ projects will be implemented. Using data from many sample plots in various forest types in Cambodia, here we attempted to estimate carbon stocks by province by forest type in Cambodia. Our results showed that total carbon stocks in Cambodia decreased from 1052.5 TgC in 2002 to 1020.0 TgC in 2006, resulting in emissions of about 27.9 TgCO2 year-1. The following provinces had the highest carbon stocks in Cambodia: Preah Vihear, Mondulkiri, Stung Treng, Kratie, and Koh Kong. Provinces responsible for the highest carbon emissions in Cambodia were Battambang (18.2% of the total annual emissions), Banteay Meanchey (14.9%), Otad Meanchey (11.6%), Siem Reap (11.4%), and Krong Pailin (10.2%). In contrast, Koh Kong and Mondulkiri provinces increased carbon stocks at about -0.7 TgCO2 and -0.8 TgCO2 year-1 over the same period. Our results suggested REDD projects in the northwestern provinces are likely to achieve huge carbon credits but such projects require strong government commitment and law enforcement. If retrospective trend is chosen as reference emission level, Cambodia would generate carbon revenues of US$ 69.7 million year-1 at the price of $5 tCO2 if 50% of the current emissions are reduced.

Additional keywords: deciduous forest, evergreen forest, mixed forest, REDD+, stand volume

Variations of Carbon Stocks in Mixed Forests in 3 Northeastern Provinces in Cambodia
Kimsun CHHENG (Forestry Administration, Cambodia) and Nophea SASAKI (University of Hyogo, Japan)
Understanding forest carbon stocks is prerequisite for implementing and achieving the goal of the anticipated REDD+ mechanism of the United Nations Framework Convention on Climate Change. Nevertheless, study on carbon stocks in Cambodia is very...