

Forest Resource Management & Mathematical Modeling

FORMATH

International Symposium

FORMATH OKINAWA 2019

Date March, 7 (Thr) 10:00 – March, 8 (Fri) 17:00
Venue Yashio So

President

Naoto Matsumura, Ph.D. (Mie Univ.)

Committee Members

Atsushi Yoshimoto, Ph.D. (ISM)

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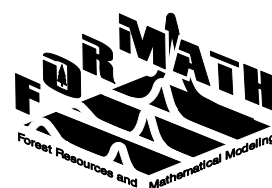
Peter Surovy, Ph.D. (Czech Univ. Life Sci.)

Tetsuji Tonda, Ph.D. (Hiroshima Prefectural Univ.)

Patrick Asante, Ph.D. (Canada BC Gov.)

Program & Abstract

Main Organizers: Risk Analysis Research Center (RARC), ISM
Co-Organizer: Japan Society of Forest Planning
FORMATH Research Group, Japan



FORMATH OKINAWA 2019
Program: March 7 (Thr) - 8 (Fri)

Date	March 7, 2019		
9:00 ~ 9:50	Registration		
9:50 ~ 10:00	Opening Remarks	Naoto Matsumura	Mie Univ. Japan
1.	Forest Policy Analysis		Coordinator: Patrick Asante
10:00 ~ 10:40	Impact of forest plantation development in Laos: A dynamic general equilibrium analysis	Somvang Phimmavong	National University of Laos
10:40 ~ 11:20	Landowners' preferences on environmentally-friendly forest management	Katsuya Tanaka	Shiga University, Japan
11:20 ~ 12:50	Lunch Break		
12:50 ~ 13:50	Poster Session I		Coordinator: Naoto Matsumura
2.	Country Profile I		Coordinator: Katsuya Tanaka
13:50 ~ 14:30	Importance of community forestry funds for rural development in Nepal	Bir Bahadur Khanal Chhetri	Tibhuvan University, Nepal
14:30 ~ 15:10	BC's Market Pricing System for Timber & Challenges	Patrick Asante	Ministry of Forests, Lands and Natural Resources Op. & Rural Dev. Canada
15:10 ~ 15:30	Coffee Break		
3.	Image Analysis & Growth Model		Coordinator: Yasushi Mitsuda
15:30 ~ 16:10	Comparison of Stereoscopic Imaging to Pinhole Camera Model with Spherical Panoramas in Measuring Tree Distance and Diameter	LAM, Tzeng Yih	Institution: School of Forestry and Resource Conservation, National Taiwan University
16:10 ~ 16:50	Appropriate growth function for tree height model of Japanese Larch	Masayoshi Takahashi	FFPRI
16:50 ~ 17:10	Coffee Break		
17:10 ~ 17:30	About FORMATH Journal		
17:30 ~ 17:45	Group Photo		
18:00 ~	Reception		

Date	March 8, 2019		
9:30 ~ 10:00	Registration		
4.	Agroforestry	Coordinator: Masayoshi Takahashi	
10:00 ~ 10:40	Institutional Dimensions of Coffee Agroforestry System in Sumatra, Indonesia	Bustanul Arifin	University of Lampung (UNILA), Indonesia
10:40 ~ 11:20	Role of Agroforestry System for Reducing Environmental Risks: A Case Study in Southwest Sumatra, Indonesia	Ryohei Kada	Shijonawate-Gakuen University, Japan
11:20 ~ 12:50	Lunch Break		
12:50 ~ 13:30	Poster Session II	Coordinator: Masashi Konoshima	
13:30 ~ 13:50	Coffee Break		
5.	Country Profile II	Coordinator: Bustanul Arifin	
13:50 ~ 14:30	Challenges of Establishing Seed Orchard for <i>Dipterocarpus</i> <i>intricatus</i> : The Cambodian Experience	Heng Sokh	Institute of Forest and Wildlife Research and Development (IRD)
14:30 ~ 15:10	Consistency improvement and accuracy assessment of activity data for forest reference emission level/forest reference level in Vietnam	Nguyen Dinh Hung	Forest Inventory and Planning Institute, Vietnam
15:10 ~ 15:30	Coffee Break		
6.	Harvest Scheduling	Coordinator: Patrick Asante	
15:30 ~ 16:10	Teak harvesting schedule to set the limits on uneven age classes -Evaluating plantation grown teak of Sri Lanka-	Rangani Wijenayake,	The University of Tokyo, Japan
16:10 ~ 16:50	Spatially Constrained Harvest Scheduling with Dynamic Harvest Treatments under Area Restrictions through Maximum Flow Problems	Ashi Yoshimoto	Institute of Statistical Mathematics, Japan
16:50 ~ 17:00	Closing	Ashi Yoshimoto	

March 7 (Thr), 2019

10:00~11:20 Forest Policy Analysis

Impact of forest plantation development in Laos: A dynamic general equilibrium analysis

Somvang Phimmavong (National University of Laos)

This paper examines the economy-wide impact of forest plantation development in Laos using a recursive dynamic computable general equilibrium model. Analysis focused on the Government of Laos' forest policies to promote the development of forest plantation by the year 2020. Simulation results show that this forestry policy is likely to have a positive impact on the Lao economy by increasing the production of forestry and forestry related industries and by stimulating exports and household income. Impacts are more significant for the Forestry and Forest-related sectors. Despite some undesirable impacts on sectors that do not have strong interactions with the Forestry sector from the short to medium runs, production of these sectors is likely to recover in the long run, and enjoy increases in their production in all sectors by the end of the projection.

Landowners' preferences on environmentally-friendly forest management

Katsuya Tanaka (Institution: Shiga University)

While traditional forest management shows deadlocks, forest management shortages and management abandonment are becoming serious at the nationwide scale. As a result, multi-functionality (ecosystem services) of forest has been declining in insufficiently managed forests, and deterioration of biodiversity conservation function, water source recharge function, sediment disaster prevention function, etc. are major problems. In order to maintain the multifunctional function of the forest by appropriate management, it is necessary to induce policies from traditional forest management to environmentally friendly form. This study analyzes landowners' preference on acceptance of environmentally-friendly forest management using the best-worst scaling. Survey was conducted in 2017 to about 150 forest owners in Shiga Prefecture. As a result of the mixed logit model analysis, (1) the needle broad mixed forest tends to be strongly supported by respondents, the long-harvesting operation continues, and the conversion to broadleaf forests is not the most favorable. (2) Receiving annual incentives is more acceptable than buying by public authorities. (3) maintaining the current situation is not supported more than any environmentally friendly measures. From these results, it can be thought that a form of paying annual incentives to shift to needle-wide mixed forests is a desirable policy option, but the level of payment to accept this policy is greatly different among respondents, considering heterogeneity. It would be quite necessary to design related policies with greater caution.

March 7 (Thr), 2019
13:50~15:10 Country Profile I

Importance of community forestry funds for rural development in Nepal

Bir Bahadur Khanal Chhetri (Tribhuvan University, Nepal)

Nepal's Community Forestry (CF) process has implied the devolution of powers to collect, retain and redistribute forest revenue from products from community forests. This study contributes to our knowledge about these important aspects of CF by presenting an analysis of the dynamic pattern of income and expenditure of 43 randomly selected Community Forestry User Groups (CFUGs) having annual income more than NRs 10,000 from Kaski District, Nepal. Results show that the CFUG three year average annual income accounts NRs 216225 and is highly skewed towards a few well off CFUGs; the high-and low average annual income of one-third of CFUGs in the sample ranges from NRs. 33116 to NRs 502363. Timber income and the user's contribution constitute the most important sources of income comprising of 40 % and 25 % respectively. The rural development investments of CFUG income is also highly variable, and is shaped by two major characteristics: one the income size of CF, and the other socio-political and contextual factors, such as representation of dalit in executive committee, number of households in the group, donor support etc. Overall, 44% of the CFUG income is invested in community development and 37% in forest conservation. Investment in community development increases with rising income. Accordingly, the results presented here provide insights to promote community forests to generate more income which, indeed, could be a vehicle for community development as it appears in the mid-hills of Nepal.

BC's Market Pricing System for Timber & Challenges

Patrick Asante (Ministry of Forests, Lands and Natural Resources Op. & Rural Dev.)

British Columbia prices public timber on the basis of prices set in open and competitive auctions. A representative sample of approximately 20% of the public timber supply is sold at auction. The winning bids on those auctions are then used to estimate the market value of the timber harvested by major forest companies under long term tenure arrangements with the province. This system can be described as a "hybrid" system since it combines features of competitive short term timber sales and long term tenure arrangements. In this presentation I will discuss some of the challenges of the MPS system. I will try to address concerns such as : (1) whether the British Columbia Timber Sales (BCTS)/MPS system is a sound market-based system for determining market value; (2) whether bids for timber rights sold at auction by government (through BCTS) are valid market prices; (3) whether these BCTS bids are vulnerable to manipulation by licensees or materially distorted by the predominant supply of timber from major Crown licensees whose payments for their timber rights (stumpage) are administratively set using the MPS timber pricing system; and (4) whether the MPS timber pricing system provides a reliable means of translating the winning bids on BCTS auctions into accurate estimates of the market value of the timber harvested by major licensees from their long term tenures.

March 7 (Thr), 2019

15:30~16:50 Image Analysis & Growth Model

Comparison of Stereoscopic Imaging to Pinhole Camera Model with Spherical Panoramas in Measuring Tree Distance and Diameter

LAM, Tzeng Yih (Institution: School of Forestry and Resource Conservation, National Taiwan University)

This study developed two methods of measuring tree distance, diameter at breast height (dbh), and upper stem diameter under forest canopies with spherical panoramas. A spherical panorama has 360 degree horizontal and 180 degree vertical fields of view. The first method is based on the principle of stereoscopic imaging with two panoramas taken at a known vertical distance. The second method is based on the pinhole camera model with targets of known size attached to sample trees. Twenty-three plots were randomly established in *Cryptomeria japonica* plantations. Sample trees were selected with a small basal area factor (BAF) for measuring dbh and horizontal distance, and were subsampled with a larger BAF for upper stem diameter. In general, the stereoscopic imaging method produced better mean accuracy than the pinhole camera model in estimating tree distance and diameter. However, both methods produced comparable precision. Moreover, results indicated that precision of both methods decreased with trees further away from a plot center, which was likely due to object space resolution of our camera system. Both methods have the potentials to extract an almost continuous set of upper stem diameters from a tree, which could improve estimation of tree volume. The stereoscopic imaging requires two panoramas to be directly on top of each other, which could be difficult to achieve in challenging terrain. The pinhole camera model requires approaching a tree to attach a target of known size, which could be an extra field effort.

Appropriate growth function for tree height model of Japanese Larch

***Masayoshi TAKAHASHI (FFPRI) Ken-ichi KAMO (Sapporo Medical Univ.)
Tetsuji TONDA (Prefectural Univ. Hiroshima)***

Tree height model is important for forecasting individual tree growth, timber production and forest carbon stock evaluation. It is also used for growth simulation of tree and stands. Applied tree height model based on growth function has been studied for decades. Due to the limitation of data, limited research and discussion was done in which growth function is appropriate for which tree species. In this study, we select appropriate growth function for Japanese larch by growth function selection using long term monitoring growth data. Three information criterion, Akaike's Information Criterion (AIC), Corrected version of Mallow's Cp (CCp), Approximated Cross-validation criterion (ACV) are used for selection of growth function among 12 models. As a result, we recommend Yoshida1, Korf, Hossfeld4 as appropriate functions for tree growth model.

March 8 (Fri), 2019
10:00~11:20 Agroforestry

Institutional Dimensions of Coffee Agroforestry System in Sumatra, Indonesia

Bustanul Arifin (University of Lampung (UNILA), Indonesia)

The study analyzes the institutional dimensions of coffee agroforestry system by taking the implementation case of sustainability certifications schemes in two coffee production centers in the Province of Lampung, Indonesia. The study specifically examines the performance of partnership between smallholders and coffee corporations, and analyzes the impact of partnership on the coffee yield, farm-gate price, and household income of the smallholder farmers. We conducted interviews with 93 samples of farmers' households in Tanggamus District, consisting of 63 farmers joining the partnership and 30 not joining, and 78 samples in West Lampung District, consisting of 35 farmers joining the partnership and 43 not joining. These households were selected using a cluster sampling method, where Nestle implementing 4C certification scheme is dominant in Tanggamus and Indocafco implementing Rainforest Alliance (RFA) certification is dominant in West Lampung. The partnership between smallholder farmers and coffee corporations are manifested by the effectiveness of internal control system (ICS) in implementing sustainability certification schemes. The ICS could serve as a bridge between incentive systems for smallholders to perform well in meeting the standards of good agricultural practices (GAP) and opportunities for large scale corporations to secure the quantity and quality of coffee beans. Smallholders joining partnership with coffee corporations perform significantly better than those of not joining, especially in coffee yield and farm-gate price. The difference in farmers' income is also driven by crop diversification (MPTS), land tenure and the degree of partnership with coffee corporations. The transaction costs of coffee value chains are significantly lower in smallholder farmers joining the partnership than those not joining. This concludes that the better the institutional arrangement of coffee agroforestry system, the more efficient the coffee value chains, hence the farmers' welfare.

Role of Agroforestry System for Reducing Environmental Risks: A Case Study in Southwest Sumatra, Indonesia

Ryohei Kada (Shijonawate-Gakuen University)

Increasing ecological risks and greater impacts of climate change are among the most serious threats to many Asian countries. High economic growth, population increase, industrialization and rapid urbanization have not only affected the sustainability of natural resources and socioeconomic systems, but also endangered food and health security of the people. Drastic changes in water system and land use patterns in many watersheds have caused serious damages and expanded natural disasters such as flooding and soil erosion. Those damages not only result in huge economic loss but also affect serious public health issues in the urban areas located downstream, and pose a threat to the food security of the people, as typically shown in Sekampung watershed in Sumatra, Indonesia. In examining the significance of agroforestry, we conducted a thorough household survey by interviewing 408 coffee farmers in two sub-districts in the upper Sekampung watershed. This watershed not only serves as major food baskets such as rice, maize, cassava, and fishery products, but also produces major export commodities such as coffee, cocoa, palm oil, and coconut. Agroforestry system has provided additional income sources, mostly from tree species, shown by significant higher B/C ratio than the coffee farm only. Supply chain certification programs have attempted to create price premiums at the farm level, where Rainforest Alliance and 4C certificates have been around in the study sites for about 5 and 2 years respectively. One significant observation is that stakeholders' participation is an important factor to achieve sustainable ecosystem services in regional communities. Our study has revealed an important role of major stakeholders and involvement of local authorities.

March 8 (Fri), 2019
13:50~15:10 Country Profile II

Consistency improvement and accuracy assessment of activity data for forest reference emission level/forest reference level in Vietnam

Nguyen Dinh Hung (Forest Inventory and Planning Institute, Vietnam)

Vietnam has successfully submitted its initial forest reference emission level/forest reference level (FREL/FRL) in 2016 and the technical assessment report (TAR) for Vietnam's FREL/FRL has been released in 2017. Vietnam FREL/FRL was established based on four historical forest cover maps (1995, 2000, 2005 and 2010). These forest cover maps were developed by Forest Inventory and Planning Institute (FIPI) based on different methods and different types of satellite imagery. The TAR recommended Vietnam to: "use of a consistent approach to geospatial image interpretation across the time series to ensure coherent interpretation and to enhance accuracy". In addition, although the current FREL/FRL submission has already described a method for accuracy assessment of activity data, the process has not completed yet. To improve Vietnam FREL/FRL, it is necessary to improve the consistency of historical forest cover maps and complete the accuracy assessment of activity data. In this work, we upgraded the maps using an automated method for forest change detection based on multiple time-series Landsat data to make them more consistent. We also conducted accuracy assessment for these upgraded maps, and adjusted activity data based on the results of accuracy assessment. The results show that the areas of evergreen broadleaf forests and deciduous forest are smaller while the areas of plantation are larger in the upgraded maps as compared to the previous maps. Although the overall accuracy (~96%) and producer's accuracy (90%-97%) of the activity data are quite high, the user's accuracy of activity data for forest degradation (29%-50%) and forest restoration (18%-25%) are rather low. This reflects the fact that monitoring forest degradation and restoration using Landsat imagery is quite difficult. Therefore, data directly extracted from the maps are not reliable enough and should be adjusted based on the results of sample-based accuracy assessment.

Challenges of Establishing Seed Orchard for *Dipterocarpus intricatus*: The Cambodian Experience

Sokh Heng (Institute of Forest and Wildlife Research and Development (IRD))

Seed orchard is viewed as the most important and reliable source of planting materials, especially in forest restoration and commercial timber plantation. Cambodia is in the process to establish her first ever seed orchard to support the forest restoration in degraded forest lands. The Forestry Administration of Cambodia is implementing the project entitled "Establishment of Forest Genetics Research Center for Restoration of Major Timber Species in Cambodia" funded by ASEAN-ROK Forest Cooperation (AFoCo). The project is part of the initiatives in Cambodia to restore the degraded and denuded areas. The project seeks to implement the long-term tree breeding plan by conducting a plus tree selection, establishment of progeny test plantation and establishment of clonal seed orchard. The Seed Orchard is expected to be the source of planting materials for the three species, *Dipterocarpus intricatus*, *Dalbergia cochinchinensis*, and *Pterocarpus macrocarpus*. *Dipterocarpus intricatus*, a valuable source of resin to communities in Cambodia. Several component studies were conducted by the project: (1) Asexual propagation trials of the three species (Grafting, Cutting and Tissue Culture); and (2) Progeny Testing. Scions and seeds were collected from various Plus Trees all over Cambodia. Data collection are currently being conducted for statistical analysis and will be used as basis in selecting the superior mother trees. Rouging will be conducted to the planted seedlings in the seed orchard based on the outcome of the analysis. Among the challenges encountered by the project is the very short longevity of seeds of *Dipterocarpus intricatus*. The trials show that *Dipterocarpus intricatus* will not respond to grafting, cutting and tissue culture. Due to the failure of asexually propagating *D. intricatus*, the project used seedlings in establishing the seed orchard. Finding ideal sites (i.e. isolated sites/free from naturally growing *D. intricatus*) is very difficult. Thus the risk of pollen contamination is still high due to the presence of naturally growing *D. intricatus*.

March 8 (Fri), 2019

15:30~16:50 Harvest Scheduling

Teak harvesting schedule to set the limits on uneven age classes -Evaluating plantation grown teak of Sri Lanka-

Pavithra Rangani Wijenayake, Takuya Hiroshima, Hirokazu Yamamoto (The University of Tokyo)

A quantitative analysis of managing teak (*Tectona grandis*) to set the limits on uneven age class structures was conducted to optimize the sustainable harvesting in government teak plantations of Sri Lanka. Certain problems combined with the management of these plantations were identified first. Current management plans for plantations of teak consist of the systematic but somewhat irrational application of the area control method. So it is difficult to rely on the current harvesting schedule to take decisions under sustainable consideration. This study was therefore aimed to formulate an alternative harvest scheduling model that integrates different management practices and site conditions. Even age mature plantations which are subjected to clear fell were selected randomly. 158 matured teak trees from teak growing regions were felled to estimate the timber volume per ha. The resulted models are useful in generating accurate and localized predictions of total timber volume and commercial timber volume which would eventually lead to better estimations on differently managed teak plantation sites. The assumption of a 40-year rotational period was applied to develop the schedule. The harvesting schedule was prepared by considering constant log demand per year (32,000m³/yr). This study confirms that harvestable volume differs with the site condition, so it is essential to determine the harvesting regions by referring to developed harvesting schedule. The proposed harvesting schedule provides a useful planning tool to manage existing teak plantations.

Spatially Constrained Harvest Scheduling with Dynamic Harvest Treatments under Area Restrictions through Maximum Flow Problems

Ashi Yoshimoto (Institute of Statistical Mathematics)

Dynamic harvest decisions or treatments in the Model II formulation over space and time, is applied to solve unit aggregation issues in spatially constrained harvest scheduling with explicit connectivity among aggregated units in each cluster. Unit aggregation is implemented by the maximum flow constraints and sequential triangle connection in the previously developed MF-Model I formulation. Spatial constraints for unit aggregation are induced from the maximum flow specification in the spatial forest unit network. Explicit connectivity of all units in a cluster is identified by sequential triangle connection. Dynamic harvest treatment used in Model II is interpreted as one-state and one-stage dynamic network and handled with temporal harvest scheduling specification, so that a decision of harvesting is defined period by period as opposed to static treatments in Model I with a treatment decision defined over the planning period.

Poster Session I
(March 7: 12:50 - 13:50)

Forecasting monthly prices of Japanese cedar sawlogs with lagged sawlog inventory level in sawmills in Japan

Tetsuya Michinaka (Forestry and Forest Products Research Institute (FFPRI))

Japanese cedar (*Cryptomeria japonica*) is the largest species among plantation forests in Japan. Mostly planted in 1950-60s, now Japanese cedar forests are mature for harvest. Understanding the changes in the price of Japanese cedar sawlogs can be helpful to forest owners and sawmills in their risk and profit management. Monthly time series price of Japanese cedar sawlogs show obvious seasonal movements, so do wooden housing start, price of Hinoki cypress (*Chamaecyparis obtuse*), and arrival, inventory, and consumption of sawlogs in sawmills in Japan. Therefore, this research firstly decomposed the national average movements of the price of Japanese cedar sawlogs and related time series and analyzed their correlations. Different correlations were found for different periods among wooden housing start, prices of Japanese cedar and Hinoki cypress (*Chamaecyparis obtuse*) within the period from January 1980 through until December 2017. Japanese cedar sawlog price was found to have a strong correlation with wooden housing start, while Hinoki cypress have a less strong correlation or sometimes even very weak correlation with wooden housing start. For the period of January 1996 to December 2017, Japanese cedar sawlog price was found to have a strong correlation with arrivals, inventories, and consumptions of sawlogs in sawmills; however, its correlations with imported Douglas fir, Hemlock fir and Northern Yezo spruce (*Picea jezoensis*) sawlogs were found very weak. Secondly, this research specified regression models of the price of Japanese cedar sawlogs on wooden housing start and inventory of sawlogs in sawmills with ARIMA errors for forecasting. By AIC, the model with one-period-lagged sawlog inventory in sawmills was chosen as the best model for short term forecasting.

Seasonal changes of hyperspectral signals of *Yushania niitakayamensis* in Taiwan

Yuan-Yi Chi, Pei-Ting Lin, Chinsu Lin, Yi-Chung Wang (National Chiayi University, Taiwan)

The *Yushania* bamboo (*Yushania niitakayamensis*) is a high mountain bamboo in Taiwan. It grows in groups at an altitude of 1100-3600m or in a sunny place. It often competes with *Abies kawakamii* for the space of fertility. In this study, the remote sensing technology was used to investigate hyperspectral characteristics of the bamboo as well as its seasonal changes, so as to evaluate the long-term development of the habitat of the bamboo using satellite remote sensing. The study site located next to the Songxue Building in Hehuan Mountain Central Taiwan. Three transect lines were deployed over the site and each of them was divided into eleven sample points. There were a number of thirty-three points collected for data analysis. The reflectance spectra were measured monthly from May to December 2015 by using the ASD spectroradiometer instrument. A continuum removal technique was applied to derive the absorption feature along the spectral regions of the blue (350nm-550nm), red (550nm-750nm), near-infrared (1120nm-1300nm), and mid-infrared (1295nm-1660nm). Results showed that the bamboo has strongest spectral absorption area in the red among the four regions during the period of July and September. This implied that the bamboo appeared to be most pronounce in physiological activities in the period which requires more light energy for growth needs. The absorption area is most correlated to the temperature, then the rainfall and humidity, and the correlation coefficient is 0.8, 0.4, and 0.3 correspondingly.

A Supervised Classification of Forest Species Using Sentinel-2 Images

Pei-Ting Lin, Yuan-Yi Chi, Chinsu Lin (National Chiayi University, Taiwan)

The spatial distribution of trees and the dynamic of forest communities are a result of their interaction with biological and abiotic factors. Mapping the composition of forest communities over times can provide critical information for assessing the impact and the history of natural and human disturbances. Meanwhile, the information can help to investigation the influence of climate change on forest ecosystem. In order to understand the possibility of satellite imagery and classification techniques for mapping the spatial distribution of major tree species in forest, a forest site located at the Lishan area in central Taiwan and a Sentinel-2 multispectral image was used for this study. According to a forest inventory, there were 10 tree species dominated the forest. With additional land uses, there were totally 15 classes used for the supervised classification using Binary Encoding Classifier, Mahalanobis Distance Classifier, Maximum Likelihood Classifier (MLC), Minimum Distance Classifier, Neural Net Classifier (NNC), Parallelepiped Classifier, Spectral Angle Mapper (SAM), Spectral Information Divergence (SID) and Support Vector Machine (SVM). Results showed that the best classification was made by MLC, SVM, and NNC with an overall accuracy (OA) of 65%, 71%, and 68%, the worst OA was 29% made by the PC method. The distribution of tree species derived by the classifications provide additional information for examining the performance of classifiers. In contrast to the distribution pattern of the trees species and land uses of the SVM, NNC, and MLC, the SVM appeared to be more robust and flexible in recognizing signatures of the classes. This is particularly evident for the trees distributed over slope shadow where most of the pixels were misclassified as water body. To conclude the experiments, without appropriate species samples from shadow area for the learning of species signatures, the SVM is more appropriate for deriving species distribution map using Sentinel-2 multispectral images.

The Effects of Compaction on Operation road construction cost and maintenance cost

Masaru Watanabe (Shinshu University)

Since the construction standard of the forest working road is not clear, the operator is constructing an operation road while judging the soil volume and soil quality. In order to build a stable road it is necessary to compact several times. However, in many cases, compaction is not sufficiently done to shorten the construction time. In previous studies it has been reported that the lines that were not compacted enough will collapse. In addition, it is thought that the maintenance cost will also increase because the road of construction defects becomes difficult due to deformation of the road surface. Therefore, in this study, we compiled the compacted section and the section not compacted, and compared the construction cost and the maintenance cost. Firstly, construction work was observed for time and construction cost was sought. After that, we investigated the shape change of the road surface for 2 years and estimated the maintenance cost. As a result, if compaction is not carried out, the construction cost will be about 60% of the normal time, but the maintenance cost has increased greatly. It is suggested that even if initial cost is required for operation roads to be used for a long term, it is more advantageous in terms of total cost to perform sufficient compaction.

Poster Session II
(March 7: 12:50 - 13:30)

Monitoring pollination service by the native honeybee (*Apis cerana*) to hyuganatsu (*Citrus tamurana*) in Aya UNESCO Biosphere Reserve

Yasushi Mitsuda (University of Miyazaki)

We monitored the relationship between pollination of hyuganatsu (*Citrus tamurana*) by native honeybees (*Apis cerana*) in Aya UNESCO Biosphere Reserve located in Miyazaki Prefecture, Japan. A total of 24 hyuganatsu trees were selected in 16 orchards, and the number of honeybees visiting each tree was counted in 2016 to 2018. Using monitoring data, we examined the relationship between abundance of honey bee as an indicator of pollination service and the landscape structure. A land use map of the study area was developed by photo interruption on the orthophoto for measuring areas of each land-use type around target trees as an indicator of landscape structures. A stochastic model for predicting honeybee visits was developed using the area of natural forest and the total area of agricultural field and grassland as explanatory variables. The difference in bee-finding ability among observers was also considered as an observation model. The estimated model parameters suggested that both the area of natural forest and total area of agricultural field and grassland positively affected pollination services by native honeybees and these effects varied with year.

The effect of spatial scale of mountainous hazard risk information on the feasibility of clearcutting

Keisuke Toyama (The University of Tokyo Forests)

Construction of forest roads and logging have possibility of inducing mountainous hazards such as shallow landslide and mudflow. The possibility is influenced by such as geographical and soil conditions, and the effect of hazards to the human society is largely varied owing to the existence of damages to human lives and properties. To find a compromise between forestry demand and risk suppression, multiple scenarios with different spatial scale of mountainous hazard risk were examined, in which high-risk woodlands are excluded from clearcutting with the cost of persuading landowners. In the assumption of this research in Kitaaike Village, Nagano Prefecture, buildings mainly located on flat area near rivers strongly affect the location of high-risk woodlands, and small woodland subcompartments such as below 0.5ha with good transportation condition are also mainly located near them. 14.0% of *Larix kaempferi* (Karamatsu) plantation in Kitaaike Village is classified as high-risk area. Excluding high-risk pixel from clearcutting area reduced 29.8% of profitable and harvestable *Larix* volume, and excluding whole subcompartments of which high-risk pixel rate are $\geq 20\%$ reduced 49.9% of profitable and harvestable *Larix* volume. When the same standard clearcutting volume was assumed, 10.0 to 14.7% of total profit of woodland owners were decreased by such exclusions and persuading costs in average. Excluding only high-risk pixel from clearcutting is often technically difficult, and persuading and negotiation costs can be higher, meaning that risk consideration can induce intensive clearcutting in large subcompartments with better condition and less risk.

Evaluation of accuracy and cost of measuring forest resources using aerial photographing by UAV

Yoshii, T. (Mie University), Numamoto, S. (Mie University), Shimada, H. (Mie Prefectural Research Center of Forestry), Ishikawa, T. (Mie Prefectural Research Center of Forestry) and Matsumura, N. (Mie University)

Japan's forest information system has a problem in the accuracy of data that serves as a basis. Therefore, it is a pressing issue to construct a highly accurate forest information database for sustainable forest management. Here, low-cost forest monitoring tools are needed for achieving adaptive management in local regions. In recent years, UAV aerial photograph and 3D modeling (Structure from Motion, SfM) are increasingly used as low-cost techniques for forest measurement. However, with a few case studies, their applicability has not been deeply discussed. In this study, four plots of plantation forest in Mie Prefecture are surveyed with UAV and SfM techniques for their forest volume estimation, and the accuracy of the information and the cost of the UAV and SfM measurement are compared. The measurement results show errors in a range of 1.4 to 7.3 m in estimated RMSE depending on the plot and in the estimated forest stand volume errors of approx. 4 – 30% in each plot. As for th

e cost, it was clarified that such survey can be carried out with the cost approx. 30% cost of the conventional method usual forest inventory. In conclusion, these techniques can secure enough accuracy for forest resource survey, but the locational conditions of a plot may affect the measurement of a the result. Thus, development of more generalized techniques are needed within the range of certain accuracy and affordable cost. Meanwhile, these techniques are verified as one alternative to serve new forest monitoring tools in view of cost effectiveness.

Consideration of forest education within limited time for non-forestry school of economics

Takeshi Ogawa (Institution: School of Economics, Senshu University)

Different to school of forestry, there is limited time to treat forestry in non-forestry school of economics. There is usually no lecture about forestry economics in school of economics, even if there are agricultural economics, environmental economics, and public economics. Of course, there are little interests of forestry for students in school of economics. Thus, the author and audiences must consider the way for teaching forestry for non-forestry school of economics within limited time. In the presentation, the author will consider the way for treating forestry as resource in the lecture of resource and energy for undergraduate students in school of economics.