森林資源管理と数理モデル国際シンポジウム

Forest Resources & Mathematical Modeling

FORMATH

International Symposium

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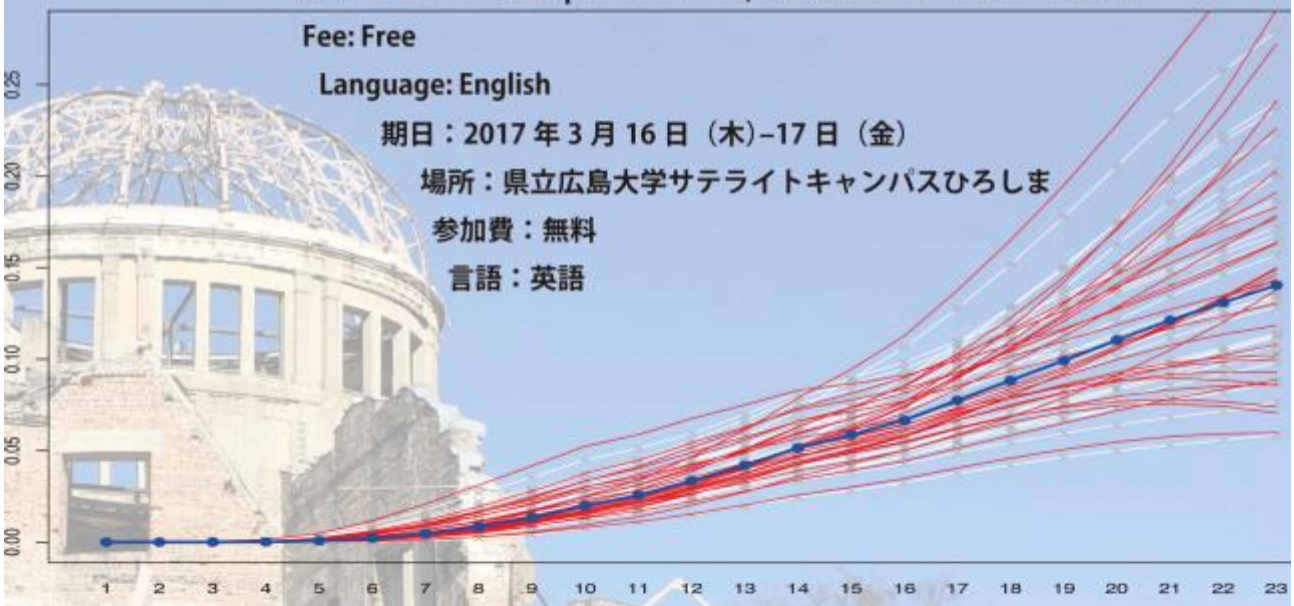

Organizer: Risk Analysis Research Center, Institute of Statistical Mathematics

Co-Organizer: Dept. of Manag. Info. Syst. Prefectural Univ. of Hiroshima

Japan Society of Forest Planning

FORMATH Research Group, Japan

主催：統計数理研究所　リスク解析戦略研究センター

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FORMATH HIROSHIMA 2017
Program: March 16 (Thu) - 17 (Fri)

(Name of presenter only. Please refer to abstract for co-presenters)

Date		March 16, 2016		
10:00	～10:40	**Registration & Coffee refresh**		
10:40	～11:00	**Opening Remarks**	Dr. Matsumura	Mie University, Japan
1.		**Carbon Issues**	Coordinator: Dr. Lin	
11:00	～11:30	Economic Analysis of Carbon Sequestration in Managed Temperate Coniferous Forest under Climate Change	Patrick Asante	BC Ministry of FLNR Operations, Canada
11:30	～12:00	CO_2 Balance Comparison between Installation of Mega-Solar Panel and Forest Management	Shizu Itaka	Joint Support-Center for Data Science Research, Japan
12:00	～13:00	**Lunch Break**		
13:00	14:00	**Poster Session**	Coordinator: Dr. Itaka	
	P01	Consumer Heterogeneity and Gains from Trade in Renewable Resource Trading -Theoretical Approach with Trade Theory based on Modern Economics-	Takeshi Ogawa	Lecturer School of Economics Senshu University, Japan
	P02	Modeling Movement Behaviors of Deer based on Telemetry Data	Yasuyuki Nishimori	Univ. of the Ryukyus, Japan
	P03	Comparing Site Index Estimation Methods using Time Series Data from Permanent Plots of Sugi (*Cryptomeria japonica*) Planted	Yasushi Mitsuda	Univ. of Miyazaki, Japan
	P04	Evaluation of Site Index Estimation Models with Machine Learning including Deep Learning	Yuki Hirose	Mie University, Japan
2.		**Cork Oak Management in Portugal**	Coordinator: Dr. Surovy	
14:00	～14:30	The Development of Adaptive Management Concepts for Sustainable use of Cork Oak Woodlands: Economic Perspectives of Multiple Use Boundaries	Nuno de Almeida Ribeiro	Univ. of Évora, Portugal
14:30	～15:00	Structural 3D Data Acquisition for DSS in Forest Management	Cati Oliveira Dinis	Univ. of Évora, Portugal
15:00	～15:30	Diachronic Studies of Cork Oak Mortality Using Aerial Imagery – A Case Study	Constança Camilo-Alves	Univ. of Évora, Portugal
15:30	～16:00	**Coffee Break**		
3.		**Assessment & Inventory**	Coordinator: Dr. Takahashi	
16:00	～16:30	Development of an R script to facilitate the processing of permanent ecological sample plots in Vietnam	Nguyen Dinh Hung	FIPI, Vietnam
16:30	～17:00	Lessons Learned from Application of SPOT-5 Images for Mangrove Mapping in the Mekong Delta, Vietnam	Do Van Thong	FIPI, Vietnam
17:00	～17:30	Eco-zone Assessment in Gabon	Ebaye Mpiga Saint-Clair	Mie Univ., Japan
18:00	～20:00	**Dinner**		

Date		March 17 2016		
10:00	～10:30	**Registration & Coffee refresh**		
4.		**Community & Monitoring**	Coordinator: Dr. Konoshima	
10:30	～11:00	The Involvement of Local People in a Scheme of Community Based Forest Management in Indonesia	Septaris Bernadetta Parhusip	Mie Univ., Japan
11:00	～11:30	Mekong Sentinel Landscape Monitoring	Sithong Thongmanivong	National Univ. of Laos, Laos
11:30	～12:00	Forest Resources Assessment by Unmanned Aerial Vehicles	Peter Surovy	CULS, Czech Republic
12:00	～13:00	**Lunch Break**		
6.		**Dynamics & Optimization**	Coordinator: Dr. Ribeiro	
13:00	～13:30	Insight into the Technique of Decompositional Stand Structure Analysis in the Research of Forest Dynamics	Chinsu Lin	National Chiayi University, Taiwan
13:30	～14:00	Optimal Sampling Design for Forest Carbon with No Bias and Minimal Spatial Autocorrelation	Sandor F. Toth	University of Washington, U.S.
14:00	～14:30	A New Exact Optimization Model for Spatially Constrained Harvest Scheduling Problems with Area Restrictions under Multiple Harvests	Atsushi Yoshimoto	ISM, Japan
14:30	～15:00	**Coffee Break**		
15:00	～16:00	**Discussion & Closing Remarks**	Dr. Yoshimoto	ISM

March 16 (Thu), 2017
11:00～11:30

Economic Analysis of Carbon Sequestration in Managed Temperate Coniferous Forest under Climate Change

Patrick Asante (BC Ministry of FLNR Operations, Canada)

Management of temperate forests has the potential to increase forest carbon sinks and mitigate climate change. However, those opportunities may be confounded by negative climate change impacts. This means that decision makers need a better understanding of the economic impact of climate change alterations to carbon dynamics before developing carbon mitigation strategies. This study, which is at its initial stages, builds on the previous work of Dymond et al 2015. The study investigates the interactions of species composition, fire, management and climate change on a temperate coniferous forest near Copper - Pine Creek Valley in British Columbia, Canada. To do so, the LANDIS-II modelling framework including the new Forest Carbon Succession extension was used to simulate forest ecosystems under four different productivity scenarios, with and without climate change effects, until the year 2050. The results implied that the species optimum growing conditions relative to current and future conditions strongly influenced future carbon dynamics. Warmer growing conditions led to increased carbon sinks and storage in the colder and wetter ecoregions but not necessarily in the others. Climate change impacts varied among species and site conditions and this indicates that both of these components need to be taken into account when considering the economics of climate change mitigation activities and adaptive management.

March 16 (Thu), 2017
11:30～12:00

CO2 Balance Comparison between Installation of Mega-Solar Panel and Forest Management

Shizu Itaka (Joint Support-Center for Data Science Research, Japan), Atsushi Yoshimoto (Institute of Statistical Mathematics)

The use of solar panel to generate electricity is spotlighted because it is renewable energy. However, installation of “Mega-solar power plant”, which is solar panel on the ground and produce more than 1MW electricity, is on the increase and became a social problem. In many cases in Japan, the Mega-solar power plants are installed after deforestation. There are growing concerns about loss of landscape, negative effect on the ecosystem, landslide, etc.. Hence the environment assessment from different aspect will be needed for installation of Mega-solar power plant. In this presentation we focused on the CO2 (carbon dioxide) balance. Our objective was to make clear the balance of the amount of CO2 for Mega-solar power plant and forest management. We calculated the CO2 balance of the various forest management pattern using dynamic programming method. The discharge of CO2 from manufacturing, installation and dismantling of solar panel, and saved CO2 amount replaced from the produced electricity, were revealed by previous study. For the presentation we will discuss about CO2 balance of these and relevant issues.

March 16 (Thu), 2017
Poster Session

P01: Consumer Heterogeneity and Gains from Trade in Renewable Resource Trading -Theoretical Approach with Trade Theory based on Modern Economics-
Takeshi Ogawa (Lecturer School of Economics Senshu University, Japan)

Both trade and management are important for not only forest but also other renewable resources generally. Focusing consumers in resource-good exporting countries, this paper focus on two-country (resource-good importing country and exporting country), two-commodity (resource good like and non-resourced manufactures), general equilibrium trading model where each country has renewable resources. In previous researches, Brander and Taylor (1998, JIE) showed that after trade, resource-good exporting country losses of trade when resource-good price does not become so higher than autarky. For example, the case includes that resource-good exporting country makes both resource good and non-resource manufactures. The reason is that resource-good exporting country uses more than autarky for making exporting goods, so resource becomes harder to use than autarky for resource-good exporting country. However, like Japanese wood and Canadian wood, resource good from resource-good exporting country and that from resource-good importing country is usually different for consumers. Therefore, even if people in resource-good net-exporting country, consumers who prefers resource good from resource-good net-importing country to that from resource-good net-exporting country gains from trade. This point also appears when consumers in resource-good net-exporting country prefers both resource goods equivalently even though consumers' preferences in resource-good net-exporting country is the same. Moreover, technical measures are used in resource good management, for example, regulation to use chainsaw, thinning to keep expensive good, and so on. Technical measures are not best way for resource management, but are used traditionally. Moreover, when people considers futures more important, the resource amount becomes nearer from the maximum sustainable yield. However, even if each country uses technical measures to maximize each country's economic welfare non-cooperatively, consumers who strongly prefer resource-good net-exporting country in resource-good net-exporting country losses of trade. This means that resource management essentially requires direct output control.

P02: Modeling movement behaviors of deer based on telemetry data
Yasuyuki Nishimori, Thanh Ha LE, Masashi Konoshima (Univ. of the Ryukyus, Japan)

Recently increased damages on newly planted seedlings and established trees caused by deer not only lower the quality and production of timber but also lead to decline in forest owners` motivation to actively manage their forests. Therefore, deer-inflicted tree damage (such as deer browse damage, bark damage) poses a serious threat to the sustainability of forest management in many rural areas of Japan. Since the spatial distribution of deer-inflicted damage depend on their movement, predicting the potential for deer damage and to identify the areas most vulnerable to deer damages based on their movement will help improve management efficiency and allocate our limited resources more efficiently. To build the foundation for understanding how damages distributed over space, we developed a deer movement simulation model based on telemetry data. We used GPS radio-telemetry data collected on 25 female adult deer in Oze national Park and surrounding areas in Tochigi prefecture, Japan (Ministry of the Environment, 2013, 2014, 2015). We developed 4 process models (1: Random Walk, 2: Correlated Random Walk, 3: Switching, 4: Core Area Movement) to recreate observed moving trajectories of deer. Moving patterns generated by our simulation models were visualized using GIS and compared with the observed moving trajectories. We also applied a similarity measure presented by Yanagisawa et al. (2003) to quantify the similarity of movement paths between the observed and simulated trajectory data. Our results showed that the Core Area Movement (CAM) resembled the observed moving trajectory well. Therefore, we extended the CAM model to incorporate habitat bias in order to improve the realism of the CAM model. Here, we considered topography and vegetation cover types. In our extended model, deer successfully avoided steep slope ($> 50^{\circ}$) areas as observed in our samples. Also, in our simulation model deer avoided the area with vegetation cover types where observed deer have never visited.

P03: Comparing site index estimation methods using time series data from permanent plots of sugi (*Cryptomeria japonica*) planted stand
Yasushi MITSUDA (University of Miyazaki)

We estimated site index of sugi (Cryptomeria japonica) planted forests using permanent plot data by three method; 1) guide curve method, 2) difference equation method, and 3) hierarchical Bayesian method. Site index prediction models were developed using estimated site indices by each method as the objective variable, in which topographic variables derived from digital terrain analysis were used as explanatory variables. The developed site index prediction models were examined by the precisely measured site index data derived from stem analysis. The site index prediction models derived from site indices estimated by guide curve and difference equation methods could not represent variations in validation data, while estimated site index by the site index prediction model derived from hierarchical Bayesian method was strongly correlated to validation data.

P04: Evaluation of Site Index Estimation Models with Machine Learning including Deep Learning
Yuki Hirose (Mie University)

In Japan, site index has been estimated based on the relationship of topographical conditions with linear models such as multiple regression analysis and Quantification Method Type I in general. However, Minowa et al. (2005, 2009) assumed that forest dynamics were nonlinear, estimated the site index with higher accuracy using some machine learning models, e.g. support vector machine, random forest, and neural network. In recent years, the neural network algorithm has been remarkably developed to a new machine learning method called “Deep Learning”. Recent research in various fields revealed that its accuracy and versatility are higher than the conventional models; nevertheless, methodology of estimating the site index by the deep learning is not confirmed at present. The purpose of this study is to analyze and compare the classification accuracy of site index estimation models by the methods of deep learning and the other machine learning used in the previous research in Japanese cedar forest, and finally to estimate the site index in the whole case study area using the deep learning as a model with the highest accuracy. Input data to a model consisted of seven topographical factors based on GIS analyses. The result showed that deep learning model had the highest accuracy of all object models in terms of ratios of correct discrimination and F-score from the 10-fold cross validation. In addition that the spatial distribution of the estimated site index largely agrees with existing ecological knowledge, this study suggested applicability of deep learning for estimating site index.

March 16 (Thu), 2017
14:00～14:30

The Development of Adaptive Management Concepts for Sustainable use of Cork Oak Woodlands: Economic Perspectives of Multiple Use Boundaries

Nuno de Almeida Ribeiro (University of Évora, Portugal)

The implementation knowledge transfer policies, linking university and research centers to stakeholders through forestry is fundamental to the sustainable use of of forest resources. In the cork woodland production system the most significant part of income of forest oak production is obtained from cork, which only comes a long period after the investment is made (usually the first revenue from cork comes 28 years after planting). Therefore, cork production is a very long-term maturity investment that requires long run sound policies (public and private) to reach the production objectives. An ecological based decision support system ECCORK 2.0 was developed under the environment of cork oak spatial tree growth simulator CORKFITS 3.0 incorporating a set of ecological and economic variables that are fundamental to the process of decision making in the management of cork oak stands. In the present work, it is presented the comparison of different cork oak initial density and cattle per hectare combinations. Using as economic/financial indicators the Net Present Value, NPV, and the Annual Net Return Equivalent, ANRE, a set of combinations of trees and cattle densities were evaluated in a long-run sustainable perspective. The results indicate that cork oak production long-run sustainability is dependent of tree density and stand structure management in time, through precise thinning and regeneration regimes, judicious prices for cork; and limited number of cattle per hectare. This production system is highly relevant regarding that cork oak woodlands dominate the landscape of the south-western Iberian Peninsula, occupying approximately 0,574 million hectares in Spain and 0,737 million hectares in Portugal that represents approximately 61% of world area and 80% of world's cork production.

March 16 (Thu), 2017
14:30～15:00

Structural 3D Data Acquisition for DSS in Forest Management

Cati Dinis (University of Évora, Portugal)

Accurate determination of structural tree model is necessary for a variety of applications concerning forestry, ecology, urban forestry among others. Exhaustive 3D plant digitizing continues to be considered the most accurate way to describe plant architecture with less errors. The 3D digitizing method has been used since the 70's, firstly with an articulated arm measuring rotation angles. Nowadays more advanced technologies are applied such as semiautomatic measurement of 3D canopy and root architecture using a 3D digitizer. A precise and detailed tree reconstruction can be achieved using special equipment of 3D digitizing – Polhemus Fastrak - recording the 3D position of sensors inside a magnetic field created around the target. However, due specially to time consuming and equipment costs a novel approach to modelling tree size and structure in three dimensions using photo-reconstructed models through common cameras is becoming an interest study subject. This new approach has various potential advantages over traditional methods, including reducing measurement time, errors and eventually accurate estimation of total tree volume. It will be presented some examples of 3D data acquisition for cork oak aerial and belowground structures using the abovementioned methodologies. Also it will be showed how and what the role of these advanced methodologies in Decision Support Systems in Forest Management in Portugal.

March 16 (Thu), 2017
15:00～15:30

Diachronic Studies of Cork Oak Mortality Using Aerial Imagery – A Case Study

Constança Camilo Alves (University of Évora, Portugal)

Tree mortality is usually a complex phenomenon involving the combination of several bio/ abiotic factors causing loss of tree resilience and making them vulnerable to plagues and diseases. Aerial imagery and GIS techniques are widely recognized to survey tree mortality. Here we applied them in diachronic studies of cork oak decline in 2 silvopastoral farms (□300 ha each) located in south Portugal, where mortality events have been observed since early 00's. The goal was to identify factors related to cork oak mortality, like site characteristics, cultural practices, plagues and diseases. A combination of RGB and IR aerial photography allowed the detection of the dead trees. Using GIS aerial images were crossed with soil maps to create polygons with one value for soil type, slope, aspect and crown cover. The methodology as applied to aerial images obtained in 2004 and 2012. Kernel density of dead trees was used to select areas for field prospection, particularly the soilborne pathogen Phytophthora cinnamomi. Information gathered with landowners was also incorporated in the study. The pattern of mortality from 2004 to 2012 allowed the identification of site characteristics that made trees more vulnerable, predisposing them to decline; also allowed to rank the factors associated to decline and to detect mitigating factors. This approach aided to define strategies to mitigate tree decline and is a good tool in forest management. Cork oak decline is due to complex processes that should be analyzed in an integrated approach, where mortality is a function of several factors acting conjointly.

March 16 (Thu), 2017
16:00～16:30
Development of an R script to facilitate the processing of permanent ecological sample plots in Vietnam
Nguyen Dinh Hung (Forest Inventory and Planning Institute)

There is a system of 260 permanent sample plots for studying ecological issues in Vietnam. This system of sample plots has been inventoried since 2013 and so far data of 92 sample plots are available. This research aims to develop a tool to facilitate the processing the data of permanent sample plots. Methods for calculating the forest stand parameters, biodiversity indicators were selected. A goodness of fit based on chi-squared test was also developed for fitting the tree diameter distribution. A script written in R was developed to implement the selected methods. Data of three permanent sample plots were used to test the R script. The results show that the R script works well and therefore can automate the processing of permanent ecological sample plots to avoid human-induced errors. In future work, the R script will be extended to calculate average estimates for forest attributes as well as their confidence intevals across ecological regions to improve the usefulness of the tool.

March 16 (Thu), 2017
16:30～17:00
Lessons learned from application of SPOT-5 images for mangrove mapping in the Mekong Delta, Vietnam
Do Van Thong (Forest Inventory and Planning Institute)

Mekong Delta has a total area of nearly 4 million hectares, accounting for 12% of total natural area of the Vietnam. There are 13 provinces, with a population of over 18 million people. This is one of the risk areas severely affected by climate change and rising sea levels. Therefore, mangroves in this region have particularly important role in protecting the coast, limiting the harmful effects of wind, waves, storms, erosion reduction, environmental protection, reclamation. The mapping of mangrove forests to provide full information on the distribution, area, quality and predict changes of forests in the future is necessary to serve management, protect and develop of the mangroves forest to adapt to climate change. By using satellite images of high resolution (SPOT 5) through image interpretation methods automatically combined with additional field surveys, research results have identified the current state about area, volume, age, species mangrove forests of the Mekong delta for each forest plot, according to managers, according to the intended use (special, protection, production) and according to the level of administrative units (communes, districts , provincial). research results have been fully integrated, detailed in a map database with 51 fields of information help to search information and extract data quickly and accurately, service for the management, monitoring and identifying solutions to improve forest quality consistent. The study results also showed that the experience to build a forest map correctly depends on image quality, image sampling results and the determination of the parameters, index to automatic image classification.

March 16 (Thu), 2017
17:00～17:30
Eco-zone Assessment in Gabon
Ebaye Mpiga Saint-Clair (Mie University)

Major problems of the Congo basin forest area in Central Africa and to Gabon specifically, are losses of canopy cover (deforestation) due to human activities. Eco zone assessment could be useful to study the inter-relationships between ecosystems and human activities in order to know what kinds of landforms in the region are best for some activities such as forest conservation or forest product. The main purpose of this study is to established eco-zone map of Gabon through GIS and remote sensing techniques. The climate condition (temperature, rainfall), Digital Elevation Model (DEM), and land cover data have been used in this study. We interpolated climate surface for Gabon land area by using weather station data gathered from a variety of source (from the 1980–2015 period). Geostatistical tools of ArcGIS were used. Geostatistical tools kriging interpolation process has been used to extract cross validation table from DEM image, kriging/cokriging interpolation are used to combine DEM image parameters with weather station data. Semivariograms were applied to determine the influence of spatial dependence on neighborhoods of sample points selected to predict unknown points. The Gabon land cover map was derived from original raster based Globalcover Afrique Central archive. It has been post-processed with Idrisi Terrset. Spatial Decision Modeler is used to combine

climate and land cover map with DEM image in order to generate eco-zone map of Gabon. In Conclusion, three eco-zones were proposed with some differences in terms of Landform and vegetation.

March 17 (Fri), 2017
10:30～11:00
The Involvement of Local People in a Scheme of Community Based Forest Management in Indonesia
Septaris Bernadetta Parhusip (Mie University)

The involvement of local people in forest management is a mean to enhance poverty alleviation. In Indonesia, it has been applied through a community-based forest management scheme named PHBM (Pengelolaan Hutan Bersama Masyarakat) which involves government, state owned forest company, and local farmers. A study has been conducted in PHBM in Ciomas, Bogor; West Java – Indonesia from 2005 until 2010. The objective of the study is to examine the effectivity of PHBM in Ciomas by identifying people motivations to participate in PHBM, people perceptions towards PHBM, problems in the implementation of PHBM, farming system preferences, alternative job preferences, and tree species preferences. Primary data were collected by conducting interviews and distributing questionnaires to gain results. Local people are motivated to participate in PHBM by the revenue obtained from the timber sale. At first, local people presumed that PHBM was fairly applicable to increase their income. Problems faced by PHBM are illegal logging and plantation insecurity caused by cattle and fire. By counting benefit-cost ratio (BCF) of some farming system in PHBM, farming system which involved paid laborers is considered not feasible. Beekeeping is one of alternative job preferences to support the value of PHBM. Acacia mangium as timber tree species and Nephelium lappaceum as multipurpose tree species are the most existing and most preferred species during the implementation of PHBM in Ciomas.

March 17 (Fri), 2017
11:00～11:30
Mekong Sentinel Landscape Monitoring
Sithong Thongmanivong (National University of Laos)

Mekong sentinel landscape is a collaborative research project undertaken by five academic institutions, established to monitor the socio-ecological processes in the Mekong region. The specific objectives are to examine the access, distribution and use of ecosystem services in the context of Mekong region, identify the link between socio-economic aspect and the resource degradation. Beng district in Udomxay province was selected as case study for Laos. In 2015, an area of 100 km2 (10x10km) was identified and conducted the field data collection, including the socioeconomic and its ecological status survey. Highlights of findings from the surveys and propose plan for the coming phase will be presented in this Symposium.

March 17 (Fri), 2017
11:30～12:00
Forest Resources Assessment by Unmanned Aerial Vehicles
Peter Surovy (Czech University of Life Sciences)

Unmanned Aerial Vehicles (UAV) or Unmanned Aerial Systems (UAS) has become increasingly popular among researchers in last years, due to their capacity of providing ultra-high spatially resolution data and also due to their operability within short period of time. The trends indicate that the development of this technology is intensive and the national business plans and legislation steps ensures that the future will be favorable for utilization of drone technology especially in sectors like agriculture and forestry. In this presentation will be shown the current state of the art of practical forestry applications based on recently published research as well as on ongoing projects in various countries and various forest systems where the authors are involved (from disturbance areas, through plantations to mature stands). One of the main challenges in data processing is statistical analysis of point clouds and the data extraction from them. We present here some novel algorithms for point cloud analysis and present the potential outcomes with their accuracy.

March 17 (Fri), 2017
13:00～13:30

Insight into the Technique of Decompositional Stand Structure Analysis in the Research of Forest Dynamics

Chinsu Lin (National Chiayi University)

Recently, a novel technique of decompositional stand structure analysis (DSSA) was developed for extracting forest dynamic information in terms of multiple attributes and their interactions. The DSSA technique integrates species-based probability density function fitting (SBPDFF) and growth modelling (GM) of tree-size parameters to retrieve chronological information of individual trees within a forest stand. This enables investigation of the features of diameter, height, and age structures and the changes in the abundance, survival, and mortality rate of the predominant species in a forest canopy. Traditionally, the research of forest dynamics has been mainly involved a single volumetric parameter such as the modelling of forest diameter structure. It is probably due to a practical need of basal area and/or stock volume determination. Because the influence of global change on the Earth has been significantly increasing, the need of simultaneously exploring changes of forest multiple attributes has become crucial and should be continuously implemented over a wide range of forest ecosystems. DSSA provides an effective approach to satisfy such needs. The objective of this paper is to highlight the basic principles of DSSA techniques to forest societies. A practical use of DSSA is also briefly demonstrated.

March 17 (Fri), 2017
13:30～14:00

Optimal Sampling Design for Forest Carbon with No Bias and Minimal Spatial Autocorrelation

Sandor Toth (University of Washington, Seattle)

Can we design an unbiased spatial sampling strategy for forest carbon in remote regions that would minimize the expected variance on an estimated population mean subject to budgetary and logistical constraints, as well as concerns about spatial autocorrelation? In other words, can we design a sampling protocol with minimal spatial auto-correlation and with non-zero inclusion probabilities for each member of the population of interest across space while meeting hard constraints on infrastructural and budgetary reality? I will explore these questions in the context of an integrated ground- and air sampling effort for six carbon pools in remote boreal forests of Alaska. The goal is to minimize the expected variance on estimates of mean carbon tonnage in six forest pools by optimal flight path selections for remote sensing and by optimal vehicle routing for ground calibration. Perhaps for the first time, we study the relationship between spatial optimization and unbiased statistical sampling in an attempt to find ideal designs that are both viable on the ground, in the air and in the face of statistical theory.

March 17 (Fri), 2017
14:00～14:30

A New Exact Optimization Model for Spatially Constrained Harvest Scheduling Problems with Area Restrictions under Multiple Harvests

Atsushi Yoshimoto (Institute of Statistical Mathematics)

We propose a new exact optimization model to solve spatially constrained harvest scheduling problems with the minimum and maximum opening size constraints. The proposed model utilizes the idea of maximum flow problems to specify forest unit aggregation. Spatial connection for forest unit aggregation is conducted by forming a set of continuous triplet connections under the adjacent relationship of Moore neighborhood. An area restriction problem is formulated in order to identify the best set of forest unit aggregation subject to the given area limits. No pre-defined rule for creating possible clusters or candidates is necessary, which allows one to solve this kind of problem with commonly available spatial adjacency information including Moore and Neumann neighborhood. The resultant formulation follows the definition of treatments for multiple harvests controlled by activity adjacency information. This avoids concurrent harvests among adjacent forest units, aggregated or non-aggregated.