2025

SOMENS & NEMO

Fernandina Beach, Florida

Joint Southern and Northern Mensurationists Meeting

October 26 – 28

Courtyard Amelia Island

Welcome to SOMENS & NEMO

Southern Mensurationists (SOMENS)

We are an informal group of forest biometricians, mensurationists, statisticians, mathematicians, modelers, computational foresters, and other practitioners whose professional interests include:

- Quantitative Management: Sustainability Analysis; Financial & Risk Analysis; G & Y; OR; Optimization; etc.
- Plantation Management: Spacing; Vegetation Control and Fertilization; Irrigation; Genetic Engineering; etc.
- Computational Forestry: Simulations; Programming and Software Development; Internet Applications; etc.
- Inventory Issues: Inventory, FIA/SAFIS Related Matters, Updates; Surveys; Sampling; Site Determination; etc.
- Modeling: of G&Y, Processes and Landscape; Models & Validation; Parameter Estimation; N-lin. Mixed Effects; etc.
- Data: Relational & Distributed Databases: Design, Programming, Management, Maintenance and Use; Data banks; etc.
- Other: Methodologies; Algorithms; Mathematical Methods; Harvest Scheduling; Multi-Criteria Decision Modeling; Remote Sensing and GIS; Land Use Changes; Supply Analysis; Econometrics; Decision Analysis; Expert Systems; Management Diagrams; etc.

Our objective is to host a meeting on topics and current developments and interests relating to all aspects of Measurements and Quantitative Methods and Management in Forestry and other disciplines. The meetings will be open and all individuals interested in the above topics are encouraged to attend the annual meetings. Such meetings provide a great environment for exchanges of ideas and opportunities for relaxing as well as a productive atmosphere for joint work.

Northern Mensurationists (NEMO)

The Northeastern Mensurationist Organization (NEMO) was organized by foresters with an interest in quantitative methods to provide a place where, once a year, we could get together and share some of the important research, policy, and practical concerns in the northeast. The guiding principle has been that the meetings should be casual, yet professional and open to all

with an interest. To that end, we have encouraged holding meetings at locations where it would be within the reach of all, including graduate students. Our success rate in meeting these goals is pretty close to 100%. In addition, the level of presentation is encouraged to be gentle and accessible to all, while not sacrificing content. Graduate students are especially encouraged to think of NEMO as a friendly place to get feedback on their proposed research work.

Though we founded NEMO to provide a place to share information of regional interest (the northeastern U.S. and Canadian Maritime provinces), anyone is welcome to come and join in the discussions or offer a contributed talk, as many topics transcend regional boundaries. As the agendas for previous years will attest, we have had attendees from other parts of the country, with the 2000 meeting being a joint meeting in cooperation with the Midwest Mensurationist Organization, and 2003 with the Southern Mensurationist Organization.

2025 Organizing Committee

Co-Hosts:

- Corey Green, Virginia Tech
- Cristián Montes, Rayonier

Organizing Committee:

- Micky Allen, Larson and McGowin
- JohnPaul McTague, Retired Rayonier
- Sheng-I Yang, University of Georgia

Sponsors and Participating Organizations

Thank you to our sponsors for their generous support of SOMENS/NEMO this year!

Agenda

Sunday, October 26th

Optional boat tour and icebreaker: 5:00 pm – 7:00 pm

Monday, October 27th

Coffee and pastries: 7:30 am – 8:00 am

8:00 am – 8:05 am	Introduction and welcome (Lighthouse Room)	
8:05 am – 9:00 am	Quang Cao *Louisiana State University*	Keynote Address: *Growth and Yield Modeling Then and Now – My Perspective*

Session 1: 9:00 am – 10:30 am

	Lighthouse Room	Harbor Room
9:00 am – 9:30 am	Micky Allen *Larson and McGowin*	Yuhui Weng *Stephen F. Austin*
9:30 am – 10:00 am	Caddis Fulford *Rayonier*	Brian Foster *Foster Forestry and Environmental Consulting LLC*
10:00 am – 10:30 am	Mike Oppenheimer *Rayonier*	Friday Ogana *Virginia Tech*

Break: 10:30 am – 11:00 am

Session 1: 11:00 am – 12:00 pm

	Lighthouse Room	Harbor Room
11:00 am – 11:30 am	Cristián Montes *Rayonier*	Lu Zhai *Oklahoma State University*
11:30 am – 12:00 pm	Mike Strub *Retired, Weyerhaeuser Company and Adjunct Professor at Virginia Tech*	Tao Liu *University of Georgia*

Lunch: 12:00 pm – 1:30 pm

Session 3: 1:30 pm – 3:00 pm

	Lighthouse Room	Harbor Room
1:30 pm – 2:00 pm	Stephen Kinane *University of Georgia*	Suveksha Jha *Larson and McGowin*
2:00 pm – 2:30 pm	Corey Green *Virginia Tech*	Mauricio Zapata *Rayonier*
2:30 pm – 3:00 pm	Qianqian Cao *Virginia Tech*	Dehai Zhao *University of Georgia*

Break: 3:00 pm – 3:30 pm

Student Session: 3:30 pm – 4:50 pm

	Lighthouse Room	Harbor Room
3:30 pm – 3:50 pm	Ben Protzman *Virginia Tech*	Tara Skiba *University of Tennessee*
3:50 pm – 4:10 pm	Samjhana Wagle *University of Georgia*	Mimi Pinyan *University of Georgia*
4:10 pm – 4:30 pm	Dinuka Senevirathne *University of Georgia*	Esther Kemigisha *Stephen F. Austin*
4:30 pm – 4:50 pm	Noah Shephard *University of Georgia*	Nawa Pokhrel *University of Georgia*

Group Photo!

Social and Dinner at Salt Life: 6:30 pm

Tuesday, October 28th

All events will be held in the Lighthouse Room

7:30 am – 8:15 am	Coffee and pastries
8:15am – 8:30 am	Next Year's Mike Strub Challenge
8:30 am – 8:40 am	Introduction

Student Flash Talks Session: 8:40 am – 9:30 am

8:40 am – 8:50 am	Quentin Boccaleri *University of Georgia*	
8:50 am – 9:00 am	Deborah Ugaldes *University of Georgia*	
9:00 am – 9:10 am	Segun Adedapo *University of Georgia*	
9:10 am – 9:20 am	Iván Raigosa-Garcia *University of Georgia*	
9:20 am – 9:30 am	Aakriti Sapkota *Virginia Tech*	

Break: 9:30 am – 10:00 am

Student Session 10:00 am – 11:20 am

10:00 am – 10:20 am	Tianqi Li *Stephen F. Austin*
10:20 am – 10:40 am	Gabriel Macoel *University of Georgia*
10:40 am – 11:00 am	Prajwol Subedi *University of Georgia*
11:00 am – 11:20 am	Nitant Rai *Virginia Tech*

Break: 11:20 – 11:35

Mike Strub Challenge Solution and Winner: 11:35 am – 11:45 am

Speaker and Achievement Awards: 11:45 am – 12:00 pm

Lunch: 12:00 pm – 1:30 pm

Business Meeting: 1:30 pm – 2:00 pm

Adjourn: 2:00 pm

Abstracts

Keynote

Speaker: Quang Cao, Louisiana State University

Title: Growth and Yield Modeling Then and Now – My perspective

In this talk, I would like to take a little stroll down memory lane and share some of the changes I have witnessed in growth and yield modeling over the years. My focus will be on the parts I have direct experience. We will look at how whole-stand models have evolved, how diameter-distribution approaches have changed, and how stand-table projection models came into play. I will also touch on the development of individual-tree models, which opened up a whole new level of detail. Along the way, I will mention some of the efforts to link models across these different levels of resolution—trying to connect the broad, stand-level view with the finer details at the tree level. Altogether, it is a story of how our tools for understanding and predicting forest growth and yield have become more refined, more complex, and more interconnected.

Monday, Session 1

Speaker: Micky Allen, Larson and McGowin

Title: Validating the southern variant of FVS in Loblolly Pine Plantations

With increased interest in using the southern variant of FVS to model stand development in southern pine plantations, an understanding of the strengths and weaknesses of the simulator is needed. This study aims to validate the simulator for loblolly pine plantations using data from long-term observational plots established in cut-over site prepared lands. Analysis of the simulator with and without providing individual tree heights and with and without 5-year height and diameter increments will provide insight on increased accuracy and precision of collecting additional data.

Speaker: Yuhui Weng, Stephen F. Austin

Title: INCORPORATING GENETIC GAINS INTO LOBLOLLY PINE YIELD MODELING: A case study in east Texas

Incorporating genetic gains into growth and yield modeling is essential for enhancing forest management practices. This presentation will start by reviewing existing studies on this subject,

with a particular emphasis on loblolly pine in the southern United States. Following that, a case study from the western Gulf region will be discussed, highlighting two distinct models: one for loblolly pine plantations established in the late 1970s (the wood-run model) and another for those established in the 2000s with more intensive management practices, such as planting improved seed lots. We will explore the potential impacts of site index and planting density on modeling genetic gains. Additionally, long-term progeny trial data will be analyzed within both models, allowing us to compare and discuss the differences in their approach to integrating genetic gains into growth and yield modeling.

Speaker: Caddis Fulford, Rayonier

Title: Does Your Fitting Methodology Matter? A Look into Growth and Yield System Calibration

A new whole-stand growth and yield system was developed for primitively managed loblolly pine (Pinus taeda) stands in the southeastern United States. Calibrated using the original Plantation Management Resource Cooperative (PMRC) 1996 dataset, this system applies an advanced simultaneous fitting methodology to account for inherent dependencies and uncertainties among its growth functions. This model will establish a baseline yield for loblolly pine plantations, upon which future research can incorporate various silvicultural responses.

The model includes a system of simultaneous equations for dominant height, mortality, basal area, and total green weight. Specifically, a polymorphic Bailey-Clutter or Chapman-Richard's form was used for dominant height, a modified Clutter and Jones for mortality, a Pienaar for basal area, and a Schumacher-type equation for total green weight. The system was fitted using a multivariate maximum likelihood approach with latent variables, and a variance-covariance matrix was estimated to account for explicit error within each equation.

To explore the practical implications and tradeoffs of different fitting methodologies, the same system was also fitted using independent and sequential methods. The independent approach fits each component separately using observed values, while the sequential method uses predicted values from the preceding function within the system. By keeping the models and starting parameters consistent, the effect of the fitting methodology on the final system was examined. The presentation will compare the results from the independent, sequential, and simultaneous fitting methods, highlighting the practical pros and cons of each approach.

Speaker: Bryan Foster, Foster Forestry

Title: Costs and precisions of alternative plot configurations for estimating above-ground tree biomass in tropical forests

We used field measurements and sampling simulations with existing tree-level data to assess the precision of the estimates and data measurement costs for ground-based sampling inventory for above-ground tree biomass (AGB) and basal area estimation. Data were obtained from primary wet tropical forests using field measurements in Costa Rica and, for simulations, published tree-level data on Barro Colorado Island in Panama. Plot configurations and costs were compared using criteria commonly used by forest carbon offset project developers to meet precision of +/−10% at 90% confidence interval for AGB estimation.Detached plots were tested using circular fixed-area, nested, and several types of angle-count configurations. A plot divided into a cluster of sub-plots was further tested with angle-count plots. The basal area factor (BAF) used for angle-count plots varied between 2 and 20. Key findings include (i) angle-count plots emerged as a highly efficient plot configuration for forest inventories in tropical regions with high tree density and size variability with 33%–80% cost savings without precision penalties compared to the nested and fixed-area plots respectively; (ii) angle-count plots with large BAFs (3–8) are cost-efficient and can achieve low sampling errors (∼10%) with fewer plots and trees than the fixed-area and nested plots; (iii) a cluster of angle-count subplots with a large BAF (e.g. BAF = 12, 16, 20) is an efficient configuration for further investigation; (iv) small fixed-area plots for small trees with angle-count sampling for large trees is also an efficient configuration for further investigation. Among the alternative plot configurations compared, angle-count plots with their variants emerged as a highly cost-efficient and versatile alternative in complex tropical forests with visual occlusion, and are worth studying further.

Speaker: Mike Oppenheimer, Rayonier

Title: Mid-rotation Thinning Experiments – A comparison of Analysis Methods

Field trials for mid-rotation aged treatments such as fertilization were very popular in the 1970's and 80's as were their associated analysis of covariance methods for determining effects. Analysis of more recent mid-rotation thinning experiments have either employed covariates haphazardly or omitted them altogether. This can be partially attributed to the unique challenge thinning treatments provide when it comes to accounting for initial condition differences. Post thin treatment plots represent a subset of the initial population and as such, standard per acre covariates may lead to distorted estimates of treatment effects.

Using data from the University of Georgia Plantation Management Research Cooperative's Mid-Rotation Treatment (MRT) study, several analysis of covariance techniques will be used to determine the significance of the thinning treatment. Pros and cons of these methods will be discussed as well as some special considerations when designing a mid-rotation thinning study.

Speaker: Friday Ogana, Virginia Tech

Title: Using radiation sum as a surrogate for site index in basal area development models

Basal area is an important variable often used to describe the density of a stand, for prescribing thinning treatments, and quantifying growing stock. Projecting basal area development sometimes requires information about site productivity, usually defined as site index for planted forests or site form for uneven-aged natural forests in empirical models. Productivity is a function of the resources available to support growth at a given time, which could be impacted by climate rather than being a constant. In this study, we evaluated the potential of total radiation as a replacement for site index in basal projection models for loblolly pine in the southern United States. We used the intensively managed plantation data from the Forest Modeling Research Cooperative and the daily weather data from DAYMET to fit a modified version of an existing basal area projection model. Our preliminary results show that the hybrid model with total radiation performed better than the model with site index. Additionally, leave-one-out cross-validation revealed that the hybrid model had relatively smaller error than the site index approach. Using the total radiation also provides an opportunity to evaluate the possible impact of climate change on the basal area development. This will promote climate-smart forestry.

Monday, Session 2

Speaker: Cristian Montes, Rayonier

Title: Augmenting DBH-HT relations with environmental data to improve product estimation

Stand-level product estimation requires three estimation processes: a realistic bucking algorithm, a taper equation that is flexible enough to accommodate different sites and management regimes, and a DBH-Ht model to impute missing heights. The problems of height imputation have been looked over many times, trying to find the best equation to use for the imputation. Nevertheless, forest companies keep measuring height for every new inventory, hoping to improve product estimation, with a sometimes-reduced sample. In this research, a DBH-HT model is derived from a differential equation to account for environmental predictors, including water deficit, excess water, and available water. Sparse regression is used to select the best model to use, and the impact of noise is evaluated in the accuracy of product estimation using an optimal bucking algorithm and a non-conventional taper model. The results indicate that environmental data reduces the noise associated with the DBH-HT imputation, particularly so when local and global parameters are considered. It is also noted that the randomness present in height imputation propagates non-linearly into the taper equation, leading to unexpected results. Practitioners are encouraged to use Monte Carlo simulation to approximate the buckling problem.

Speaker: Lu Zhai, Oklahoma State University

Title: Structural Diversity is an Important Predictor of Forest Productivity Under Drought

The response of forest productivity to drought depends on biodiversity and other stand attributes. Biodiversity can regulate productivity through niche complementarity and mass-ratio effects, however with drought stress results are mixed. One emerging biodiversity metric is structural diversity, the variation in vegetation size and form. There is a lack of understanding of the interactive effects of structural diversity and drought on forest productivity. Addressing these knowledge gaps can improve the projection of forest dynamics and structural diversity-based management for drought adaptation. We compiled multiple datasets including repeated survey data of 13,059 trees in 299 plots across southcentral U.S. forests stressed by the 2010-2015 drought. We used random forest algorithm to examine how structural diversity and other factors influenced three aspects of productivity measured by aboveground wood biomass: ingrowth, growth, and net change accounting for mortality. Our results showed that: (1) Among the eight stand attributes studied, structural diversity was among the top three variables showing the greatest main and interactive effects with drought on components of forest productivity; (2) The drought-related losses in forest growth and biomass net change are exacerbated in forests with greater structural diversity; (3) Compared to diversity metrics, functional identities had greater interactive effects with drought on forest productivity (except for the ingrowth). Taken together, productivity losses related to drought increased with greater structural diversity and decreased with functional identities characterized by conservative resource strategies, such as high leaf carbon-nitrogen ratio. Thus, structural diversity and functional identity could be considered in projecting and managing forest dynamics under climate change. The comparisons between functional identity and the diversity metrics support the important role of the mass-ratio effect in forest productivity during drought.

Speaker: Mike Strub, Retired Weyerhaeuser and Adjunct Professor, Virginia Tech

Title: Using the Mellow Max Average to predict dominant height and average height by crown class.

I demonstrate how the Mellow Max Average (MelMax=ln[sum[exp[-alpha*Xi]]/n]/alpha) can be used to determine dominant height. For the Virginia Tech non-intensively improved loblolly pine data, alpha is estimated to be 0.15. Different estimates of alpha can accurately estimate average height of dominant (alpha=0.48), co-dominant (alpha=0.012), intermediate (alpha=-0.21) and suppressed (alpha=-0.75) trees. All 4 estimates had R square over 99.8%. These same estimates of the Mellow Max alpha accurately predicted dominant height and average height by crown class for the Virginia Tech intensively loblolly pine data.

Speaker: Tao Liu, University of Georgia

Title: Deep Learning-Driven Individual Tree Segmentation across Multi-Platform LiDAR Point Clouds

Dense and heterogeneous natural forests present significant challenges in tree identification due to factors such as overlapping canopies, varying tree heights, and dense undergrowth. These conditions often lead to the underrepresentation of understory trees, as laser-based methods may fail to penetrate the canopy effectively. This study introduces a novel approach for tree identification and segmentation in natural forest environments using Light Detection and Ranging (LiDAR) point clouds, circumventing conventional clustering techniques like DBSCAN and K-Means. A deep learning model was developed to enhance the efficiency and accuracy of detecting the lower sections of tree stems. The Tree Stem Identification (TSI) Model employs an inverted training approach, leveraging multiple samples from lower stem sections as primary training inputs. Approximately 30,000 samples of tree stems grown in varying forest environments—including tropical, temperate, and rainforests across the globe—were used in training the TSI model, ensuring robustness and adaptability in predicting and segmenting tree stems within LiDAR point clouds. By using the predicted lower stem section from the TSI model as a seed point, the Individual Tree Segmentation (ITS) method utilized in this study efficiently identifies and segments the tree structures above it. This approach streamlines the tree identification process by leveraging the seed point to delineate individual trees even in complex forest environments. The study utilized terrestrial LiDAR scanning (TLS) data, which provides high-density point clouds near ground level, as a critical resource for TSI model training and validation. Validation tests demonstrated that the TSI deep learning model achieved an accuracy of 0.8 in seed point prediction, significantly outperforming DBSCAN's accuracy of 0.475 under similar conditions. Furthermore, to evaluate the accuracy of the ITS method, the tree stem's diameter at breast height (DBH) derived from our approach was compared with measurements obtained through manual surveys. The ITS method exhibited a mean absolute error (MAE) of 0.01392 and root mean square error (RMSE) of 0.02006 for diameter at breast height (DBH), while the coefficient of determination (R^2) for radius was 0.9789, demonstrating high accuracy in diameter prediction. The average percentage error across all trees was 6.46%. These results underscore the model's accuracy and reliability in both seed point prediction and ITS. The proposed method's robustness and adaptability to various point cloud datasets further enhance its applicability across diverse forest environments.

Monday, Session 3

Speaker: Stephen Kinane, University of Georgia

Title: Modeling Dominant Height with Physics Informed Neural Networks

Accurate dominant height growth models in loblolly pine (Pinus taeda) plantations are critical for optimizing silvicultural treatments and projecting stand development. Traditional methods to fit dominant height models often require extensive datasets. Physics informed neural networks (PINNs) are a class of deep learning models that leverage physical laws into the neural network training process. The advantage of PINNS over traditional neural networks is its flexibility in handling noisy or sparse data, and its generalization of complex systems, providing biological interpretability by embedding differential equations that describe growth processes into the neural network's loss function. In this presentation, we explore the application of PINNs for modeling dominant height as compared to traditional methods. We leverage the Plantation Management Research Cooperative's long-term research trials to assess the performance of PINNS across a variety of scenarios to determine their utility in a modeler's toolbox.

Speaker: Suveksha Jha, Larson and McGowin

Title: Big Data, Simple Tools: Using Remote Sensing in Operational Forestry

Freely available remote sensing data are creating new opportunities for operational forestry by enabling near real-time monitoring, growth assessment, and decision support. In this study, we demonstrate how open-source datasets such as LiDAR and Sentinel-2 imagery can be transformed into practical tools that support day-to-day forest management. We developed a timber change detection framework using Sentinel-2 time series imagery to track harvest activities. Vegetation indices enabled us to identify harvested areas and produce removal maps, giving managers an efficient way to monitor compliance and plan subsequent operations. Next, we created pixel-level site index maps by deriving dominant height from LiDAR, allowing managers to visualize within-stand variability in site productivity and tailor stands accordingly. In addition, LiDAR-derived elevation models provided fine-scale topographic information, supporting decisions such as whether bedding is needed for site preparation. We also integrated LiDAR, soil, and weather datasets to model survival in newly reforested stands. This predictive framework highlights areas with higher mortality risk, enabling targeted interventions such as supplemental planting or site amendments to improve establishment success.

Together, these applications demonstrate the value of leveraging open remote sensing resources for operational forestry. By translating large-scale geospatial data into practical decision-support products, forest managers can more effectively monitor harvesting, assess

productivity, and enhance reforestation outcomes. Our results show that cost-effective, data-driven solutions are increasingly within reach for everyday forest management.

Speaker: Corey Green, Virginia Tech

Title: A new framework for designing forest samples

Forest sampling is an important activity used to produce unbiased estimates of stand parameters needed for informed management. Despite robust sampling theory and an abundance of practical experience, sample design is still challenging. This study presents an alternative approach for comparing sample designs that accounts for the cost of data collection in a discounted cash flow framework. Simulation demonstrates that there is an optimal amount of information for accurately estimating land expectation value and harvest age when accounting for sampling costs. The methodology has practical applications for selecting between contending sampling strategies and revisiting commonly applied norms in inventory programs. Ultimately, the work makes the case that sampling can be reframed as an opportunity for investment with demonstratable positive returns rather than simply a necessary cost.

Speaker: Mauricio Zapata, Rayonier

Title: Quantifying and mitigating bias and increased variability when using large-scale estimates of forests for subdomains

This research presents an empirical method for calculating a conservative discount factor when assigning estimates from a large-scale forest inventory framework to internal subdomains. This method is applicable in the context of forest carbon offset quantification, particularly when individual or aggregated carbon projects utilize the Forest Inventory and Analysis databases to produce large-scale estimates of forest stocks, which are then scaled down to project and stand-level results. The proposed correction addresses both the precision, derived from sampling variability, and the potential bias of the estimate, considering user-defined levels of risk. Neeff's 2021 study proposed a correction method to account for variability. This work extends that methodology to correct for potential bias when additional independent sample units are available within the larger project area. This research is published in: Golinkoff et al. (2025). "Quantifying and Mitigating Bias and Increased Variability When Using Large-Scale Estimates of Forests for Subdomains." Frontiers in Forest Global Change, 18 February 2025 (DOI 10.3389/ffgc.2025.1501303).

Speaker: Qianqian Cao, Virginia Tech

Title: Integrating SAE Methods with Stand-level Forest Inventory for Southern Pine Plantations

Conventional design-based forest inventory methods often lack the precision needed for reliable estimation at fine spatial scales. Small area estimation (SAE) techniques offer a

promising solution by improving precision without sacrificing unbiasedness. This study investigates the application of unit-level (i.e., plot-level) SAE to enhance inventory estimates by integrating airborne laser scanning (ALS) point clouds with field plot data from loblolly pine plantations in central South Carolina. Empirical best linear unbiased predictors (EBLUPs) were developed using a composite estimator that balances the precision of model-based predictions with the design-unbiased properties of the sample mean. The regression component of the estimator employed ALS-derived frequencies of canopy height model (CHM) classes as predictors. Results demonstrate that SAE can significantly improve the precision of volume-related estimates across a range of sampling intensities while maintaining approximate unbiasedness. Ongoing work focuses on generating stand and stock tables with greater precision than conventional methods under operational sampling conditions.

Speaker: Dehai Zhao, University of Georgia

Title: Further Discussion on Basal Area Prediction and Projection Equations

In the literature, stand basal area prediction and projection equations for forest plantations are often derived or modified from the basic form of a Schumacher-type variable density yield equation. These equations are typically based on three key assumptions: (1) stand basal area increases asymptotically with age; (2) the asymptote varies with site quality; and (3) at any given age, the basal area is positively correlated with the tree stem density and site quality. However, these assumptions may not hold for long-rotation, intensively managed plantations established across a wide range of planting densities. Consequently, simulations based on such equations may misguide management strategies, particularly those involving extended rotations or harvest deferral for carbon credit considerations. In this presentation, we propose an alternative approach to deriving basal area prediction and projection equations, and provide both theoretical and empirical comparisons between the newly derived equations and the traditional Schumacher-type yield equations.

Monday Student Session

Speaker: Ben Protzman, Virginia Tech

Title: Evaluating Crown Ratio and Crown Length as Predictors of Loblolly Pine Growth in an Individual-Tree Simulator

Crown attributes are widely used as indicators of tree vigor and competitive position in individual-tree growth models, but many crown variables are difficult to collect consistently in operational inventories. This study focuses on two field-reliable measures of crown structure: crown ratio (CR) and crown length (CL), which are evaluated as alternative drivers of increment within modified formulations of the TRULOB simulator for loblolly pine (Pinus taeda L.).

Model variants are constructed in which CR or CL serve as the primary crown-based modifier of potential height and diameter increment. Several distance-independent competition indices are also tested to examine how crown and competition effects interact within increment functions, using data from intensively managed plantations.

The objective is to determine whether CR and CL influence growth processes differently, and whether one provides more consistent performance when embedded within full growth simulations. The results will guide the selection of crown attributes for operational use in loblolly pine growth and yield modeling.

Speaker: Tara Skiba, University of Tennessee

Title: Understanding influential variables for predicting live aboveground carbon on federal southern Appalachian lands

Federally-owned forests of southern Appalachian region encompass a diversity of forest ecosystems, ranging from complex mixed hardwood forests to montane softwood systems. The limited management activity of such large, contiguous areas makes these lands particularly significant in a region otherwise dominated by privately owned lands. Some of the forest systems found on these federal lands are also strictly endemic to southern Appalachia and concerns over the health and sustainability of these forests have grown due to threats such as invasive species, natural disasters, and climate change. Updating our current understanding of which stand-level and environmental predictors significantly influence live aboveground carbon is valuable for informing monitoring efforts on these lands.

Eight national forests and two national parks located in southern Appalachia were selected for this study. Stand-level variables were compiled from permanent plot forest inventory data provided by the USDA Forest Service's Forest Inventory and Analysis (FIA) program. Due to confidentiality restrictions associated with FIA plot coordinates, a custom Python package and web application were developed to buffer the confidential coordinates before extracting environmental variable pixel values from Google Earth Engine. Various combinations of stand-level and environmental variables were tested in a hybrid parametric/non-parametric model to identify significant predictors and improve estimates of live aboveground carbon. Forest type was included as a random effect in the parametric portion of the model to account for differences between various forest ecosystems. The hybrid modeling approach leverages strengths from both parametric and non-parametric methods to enhance model interpretability and predictive performance.

Speaker: Samjhana Wagle, University of Georgia

Title: Comparing individual tree diameter growth models for loblolly pine

Loblolly pine (Pinus taeda L.) is the most economically and ecologically important tree species in the southern United States. Accurately predicting diameter growth is essential to monitor forest dynamics and health in sustainable forest management. In this study, we evaluated the prediction accuracy of individual tree diameter growth models published in the literature. Effects of stand and site level covariates in modeling tree growth were assessed. Data used were collected from the University of Georgia, Plantation Management Research Cooperative (PMRC). These findings will be useful to support the development of advanced decision-support tools for loblolly pine.

Speaker: Mimi Pinyan, University of Georgia

Title: Second Thinning Responses in Loblolly Pine Plantations: Assessment and Implications for Growth and Yield Model Development

Thinning is a common silvicultural practice in commercial loblolly pine stands across the Southeastern United States, used to accelerate growth, manipulate stand structure, and influence product class distribution at harvest. Although several models quantify stand and tree responses to a first thin, limited data availability has reduced our understanding of how stands response to subsequent thinning events. Using long-term data from the Plantation Management Research Cooperative's Mid Rotation Treatment Study, we investigated growth dynamics following second thinnings and compared these to first-thin responses in the same stands. We test the hypothesis that growth responses differ significantly between first and second thinnings and examine stand and site-level variables associated with these differences. Additionally, we assess the duration of growth response following a second thinning, quantifying how long relative growth rates remain respond after a second thinning compared to first-thinned controls. Results will inform whether existing first-thinning response models can be recalibrated to quantify second thinnings, or whether structurally distinct models are required to accurately project post-second-thinning stand development.

Speaker: Esther Kemigisha, Stephen F. Austin

Title: Extending rotation age of loblolly pine plantations for enhanced carbon sequestration and financial returns from carbon credits: Evidence from East Texas

We assess the financial viability of extending the rotation age (ER) and determine whether carbon credits generated during the ER period can offset the financial trade-offs from delayed timber harvest. We utilize a unique long-term dataset from the East Texas Pine Plantation Research Project (ETPPRP), which spans over 40 years and captures real-world growth dynamics in loblolly pine plantations, comprising a range of site productivity classes. We compared the financial outcome of two forest rotation scenarios: the Business as Usual (BAU) practice of rotation age at 25 years that provides revenue from timber only; and the ER scenario of extending the rotation age to 40 years to provide both timber and additional revenue from carbon credits. We found that the Soil Expectation Value from timber and carbon credits was positive during the extended period, suggesting that the ER option is financially viable, although this varied across age and site classes. For sites with a higher site index, the BAU rotation age (25 years) remained the optimal age, while the ER scenario had more returns than the BAU scenario, for sites with a lower site index. For a synergetic outcome, we suggest that stronger carbon markets with higher prices may enhance ER as a competitive option. Our findings provide empirical evidence that ER can deliver measurable climate benefits and offer a financially viable opportunity for landowners. This study feeds into the broader discourse on the IFM body of knowledge for mitigating climate change.

Speaker: Dinuka Madhushan Senevirathne, University of Georgia

Title: Comparing methods for estimating stand-level survival from individual tree mortality models

Accurately predicting survival over time is useful for forest managers to evaluate long-term forest productivity and health. Mortality prediction can be done at the stand and tree levels. At the stand level, mortality dynamics is often expressed through changes in stand density over time (e.g., decrease of trees per unit area with increasing stand age). At the individual-tree level, the focus shifts to estimating the survival probability of a tree as a function of time. Tree-level survival probability can then be used to estimate survival at the stand level. In this study, we evaluated alternative methods for estimating stand-level survival estimates from tree-level models. Approaches include (1) averaging tree-level probability predictions, and (2) applying probability thresholds to classify tree status (alive vs dead). Tree-level mortality was predicted using logistic regression and Cox proportional hazards models. Planted loblolly pine (*Pinus teada*) data from culture density study sites established and maintained by the University of Georgia, Plantation Management Research Cooperative (PMRC).

Speaker: Noah Shephard, University of Georgia

Title: Modeling low density loblolly pine stands for anticipated pulpwood regime change

In Southeast regions with low pulpwood prices and excess wood, loblolly pine might experience a regime change to lower planting densities. On top of low prices, mill closures have forced some landowners in pulpwood-saturated markets to pay for mid-rotation thinning – a deviation from the assumption that mid-rotation thinning generates a profit. To combat this altered pulpwood dynamic, one strategy might be to plant at low densities (i.e., <500 TPA) to (1) decrease, or potentially eliminate, the need for mid-rotation thinning an (2) decrease pulpwood proportions and increase sawtimber proportions.

With the help of G&Y systems and pricing trends, our objective is to develop a framework to aid small landowners in determining planting density for decreased pulpwood. First, we will address potential shortfalls of industry-standard G&Y systems to understand if low density silviculture can accurately be captured. This will be done by examining three Plantation Management Research Cooperatives (PMRC) G&Y systems with low density data and assessing if the models over- or under-predict production in a no-thin projection. If G&Y performance is poor, new models will be refit. Second, with estimated tonnages, we will use regional costs and prices to calculate LEV for unique Georgia physiographic and pricing regions under different planting densities, such as, 300, 350, 400, and 450 TPA. Finally, we will use an optimization function to spatially optimize planting density with LEV. Thus, providing stakeholders with the best TPA for a low-density planting system. In the future, this framework will help us to fit a low-density G&Y system to the entire Southeast and make planting recommendations to small landowners based on minimizing pulpwood production.

Speaker: Nawa Raj Pokhrel

Title: Comparison of growth and yield projections between the Forest Vegetation Simulator (FVS) and commonly used models for loblolly pine plantations in the southeastern U.S.

The Forest Vegetation Simulator (FVS) is a widely-applied growth and yield modeling framework for assessing biomass and carbon over a specified projection cycle over an extended period. The FVS Southern Variant (FVS-SN) was developed and calibrated in 2001 for the southern US. Since then, management practices in the southeastern United States have shifted toward intensive silviculture management, including site preparation, competition control, fertilization, and thinning, particularly in loblolly pine (Pinus taeda) plantations. As a result, growth and yield projections from the FVS-SN may not accurately reflect the observed measurements of these populations. However, these deviations have not been systematically assessed, necessitating the need for assessment and recalibration to maintain the model's accuracy and relevance. In

this study, we compared the performance of FVS-SN with other commonly-used growth and yield models, such as PMRC (1996) and FASTLOB (2001). Data were collected from long-term loblolly pine research trials conducted by the University of Georgia, Plantation Management Research Cooperative (PMRC) across the southeastern US. The model-projected stand variables (e.g., trees per acre, basal area per acre, total volume per acre) were compared with observations computed from field measurements.

Tuesday Flash Talk Session

Speaker: Quentin Boccaleri, University of Georgia

Title: Niche-based grouping for mixed species growth and yield models: A preliminary exploration.

Within the literature, the predominant method of growth and yield modeling for mixed species stands is to use a collection of individual species-based models, where each species is a class or strata within the larger stand. This approach requires a significant amount data for each species, which may be difficult to obtain due to limited available sites for sampling across a range of species mixes and a lack of data within existing literature. Theoretically, grouping species by shared characteristics (such as shade tolerance) could allow for strata that occupy the same ecological niche and therefore have a collective growth behavior that can be fitted to a model. This presentation will explore this concept using Forest Inventory and Analysis (FIA) and literature-derived data to fit a variety of models for stand-level basal area growth based on two strata: shade tolerant species and shade intolerant species. The results of this preliminary analysis will be used to discuss the limits of this approach and its future application in mixed species growth and yield modeling. This preliminary analysis was conducted as a part of the USDA Forest Service eYield V.2 project at the University of Georgia.

Speaker: Deborah Ugaldes, University of Georgia

Title: Quantifying the Uncertainty in Climate Variables and Its Effects on Growth Models

When performing analyses to derive one variable from another, a common assumption is that the predictor variable is measured without error. In reality, however, this assumption rarely holds, particularly when dealing with climate data. Such data are subject to multiple sources of uncertainty that must be considered in growth modeling, and various statistical techniques are available to address this issue. In this study, we examine the sources of uncertainty in climate data for temperature and precipitation, map the variance to identify areas with the greatest

variability, and evaluate the effect of this variability on dominant height projections. To this end, we compare the predictions of different growth models, highlighting the extent to which climate data uncertainty influences model outcomes.

Speaker: Segun Adedapo, University of Georgia

Title: Integrating Climate Variability into Two-Step Mortality Models to Improve Predictions for Loblolly Pine Plantations Across Southeast USA

Effective forest management depends on a clear understanding of current and future stand conditions, which are increasingly affected by climate variability. Among these changes, stand mortality poses a particularly complex challenge under shifting climatic conditions. Studies have distinguished between two primary forms of mortality: regular mortality and irregular mortality. However, traditional stand-level mortality models typically rely on stand-level variables, often not accounting for the dynamic influence of climate variability. In this study, we developed a two-step modeling approach to predict stand mortality by incorporating both climate and stand variables. We hypothesize that climate variables significantly improve the prediction of stand survival probability in southern loblolly pine plantations. Data for this study were obtained from the Plantation Management Research Cooperative (PMRC) which spans across three physiographic regions i.e., Coastal Plain (CP), Western Gulf (WG) and South Atlantic Gulf Slope (SAGS). Analysis was carried out on installations with a planting density range from 200 to 1200 planted trees per acre (PLTPA). The first step of our modeling framework estimated the probability of survival using a logistic function with predictors such as trees per acre, stand age, and relative spacing, evaluated both with and without climate variables. In cases where climate variables did not enhance predictive performance in the first stage, they were introduced in the second stage, which estimated the reduction in stem density associated with natural mortality within the stand. This approach provides forest managers with a flexible, ecologically grounded tool to understand how mortality can be driven by climate and other stand variables, thereby promoting more adaptive and resilient management strategies and a greater understanding of the drivers of stem mortality.

Speaker: Iván Raigosa-Garcia, University of Georgia

Title: Detection of brown spot needle blight using Sentinel data

Brown spot needle blight (BSNB) is a fungal disease caused by Lecanosticta acicola that affects loblolly pine plantations in the southeastern United States. The fungus attacks the needles in the lower portion of the canopy and gradually spreads upward. The resulting canopy reduction

decreases the photosynthetic surface, reduces tree growth and vigor, and makes trees more susceptible to other diseases. Humid, cool late-winter conditions and high stand density favor the development of the disease. Symptoms are typically visible in mid-winter and early spring but often disappear as new needles flush in the spring.

To characterize and quantify long-term effects of BSNB on loblolly pine plantations, field sites were established in verified symptomatic and non-symptomatic stands. Data were collected on tree size, tree health, and presence and severity of BSNB

We used Sentinel-1 and Sentinel-2 satellite imagery to differentiate between healthy and infected stands in Alabama, including both thinned and non-thinned sites. Variable selection was performed to identify relevant bands and indices for fitting a logistic regression for predicting disease presence.

Initial results suggest that BSNB can be detected during the dormant season in non-thinned stands. This represents an important step toward improving efforts in prevention before, during, and after symptom expression, while also assessing the risk of spread and estimating growth reduction due to canopy loss.

Speaker: Aakriti Sapkota, Virginia Tech

Title: Unit-Level Small Area Estimation of biomass using forest inventory plots and LiDAR-derived metrics in Northeast Minnesota

National Forest Inventories typically rely on sample inventory plots to provide estimates of forest population parameters for broad-scale assessments, such as for individual states or multi-county survey units, as reported by the United States Forest Service's Forest Inventory and Analysis program (FIA). Stakeholder requests for estimates on small geographic or demographic population subsets or domains may exceed the capabilities of the FIA design due to high variances and reduced reliability of estimates when few sample plots lie within domains of interest. Small Area Estimation (SAE) offers a promising solution by combining inventory data with auxiliary information to improve precision while maintaining approximate unbiasedness in a model-based inferential framework. The goal of this work was to demonstrate gains in efficiency using empirically best linear unbiased predictors in SAE. To achieve this goal, we performed plot-level, i.e., unit-level analyses to estimate aboveground biomass using a nested error regression modeling framework. Forest inventory observations from the Minnesota Department of Natural Resources were used as direct data, paired with high-resolution aerial lidar as auxiliary data using lidar point clouds from the United States Geological Survey 3D Elevation Program. Auxiliary predictors were selected to characterize canopy height model distributions for plots and domains in northern Minnesota with forest aboveground biomass as

the modeled response. Results will be used to inform agencies or landowners of how unit-level SAE can be used to improve the quality of information available for forest management and planning.

Tuesday Student Session

Speaker: Tianqi Li, Stephen F. Austin

Title: Size heterogeneity development in extensively and intensively managed loblolly pine plantations in east Texas

Understanding stand structure development, particularly in terms of size heterogeneity, is crucial for effective management of loblolly pine plantations. However, research on this topic remains limited. The East Texas Pine Plantation Research Project (ETPPRP) serves as a long-term, regional cooperative initiative in pine plantation productivity in the western Gulf region, establishing permanent plots in both extensively- and intensively-managed loblolly pine plantations. In these plots, tree diameter at breast height (DBH) and height have been measured repeatedly every three years. To assess tree size equality, the Gini index was calculated, while tree competition was evaluated using growth dominance for both DBH and height. The study aims to explore and compare temporal trends of these metrics as the stands develop under varying management regimes. The implications of these findings for effective management practices in loblolly pine plantations will also be discussed.

Speaker: Gabriel Macoel, University of Georgia

Title: Diameter Distribution Response to Climate Variables in the Western Gulf Region-Final Results.

Forest biometricians have developed for many decades growth and yield models to provide information about forests dynamics (e.g., tree growth, site quality, diameter increment, yield). One of these components of G&Y systems is diameter distribution models, which have been emphasized in forestry due to its effectiveness in representing stand and stock tables based on three diameter classes and provided valuable information (e.g., volume per diameter class, mortality, ingrowth, silviculture management response). Trees per acre by diameter class can be easily obtained using distribution functions. The Weibull function is one of the ways to describe diameter distributions, and it has been employed due to its flexibility and easy to apply in forest data. Although diameter distribution modeling is common and important for decision-making, few studies explore the integration of new variables or auxiliary variables, such as

environmental co-variables, into the diameter distribution modeling process. Environmental co-variables (e.g. Precipitation, soil) were found to have a significant correlation with yield and are expected to directly impact tree growth. There is a strong need to incorporate environmental co-variables into diameter distribution models, to obtain more accurate information, leading to better-informed decision-making. The parameter recovery estimation method used the percentile estimation technique included three environmental co-variables (Maximum Temperature, Precipitation and Water Deficit) to predict diameter percentiles (D0, D25, D50, D95) improved the performance as measured by AIC decreasing from -991.646 for base model to -1275.850 for accounting for environmental co-variables model, when estimated the D25 percentile. The adjusted Reynolds (1988) goodness-of-fit error index showed improvement for diameter distribution at 450 initial planting density at ages 8, 10, 15, and 18 by 6.86 %, 12.34 %, 4.86 %, and 1.51 % respectively. By including environmental co-variables in the percentile predictions, we account for their effects on DBH. When computing the Weibull three-parameter using the parameter recovery approach, the three-parameter estimation indirectly accounts for environmental co-variables. With this technique, we were able to achieve better performance in estimating the parameters of the three-parameters Weibull distribution, with a reduction in Error Index.

Speaker: Prajwol Subedi, University of Georgia

Title: Comparing the impact of canopy height models on the prediction accuracy of unit-level small area estimation for loblolly pine

Small area estimation (SAE) leverages the strength of auxiliary information and ground inventory, which has proven useful in improving the precision of estimates for stand characteristics. Among various sources of auxiliary information, LiDAR data are commonly used to build wall-to-wall canopy height models (CHMs) for SAE. In this study, we evaluated the impact of 15 different CHMs on the accuracy of the unit-level SAE models. Specifically, the uncertainty of the SAE EBLUP estimates was compared with direct estimates for all stands across the different CHM inputs. A total of 24 stands established in Wateree, SC, were used in the analysis. Airborne LiDAR data collected in 2019 were downloaded from the 3DEP LiDAR Explorer. Ground plot inventory data were collected in 2023 and were provided by Forest Investment Associates (FIA) and American Forest Management (AFM). Preliminary results indicated that both processing time and model accuracy vary among CHM generation methods. Overall, the combination of pit-free and subcircle achieves the lowest average RMSE of 4.71%, but it requires a longer processing time (1.02 min/acre), which is nearly eight times that of the progressive morphological filter (PMF) approach (0.13 min/acre). The points-to-raster approach produces the greatest average RMSE of 5.57% among all 15 combinations examined.

Speaker: Nitant Rai

Title: Deep Learning Methods for Tree Seedling Detection Using UAV Imagery

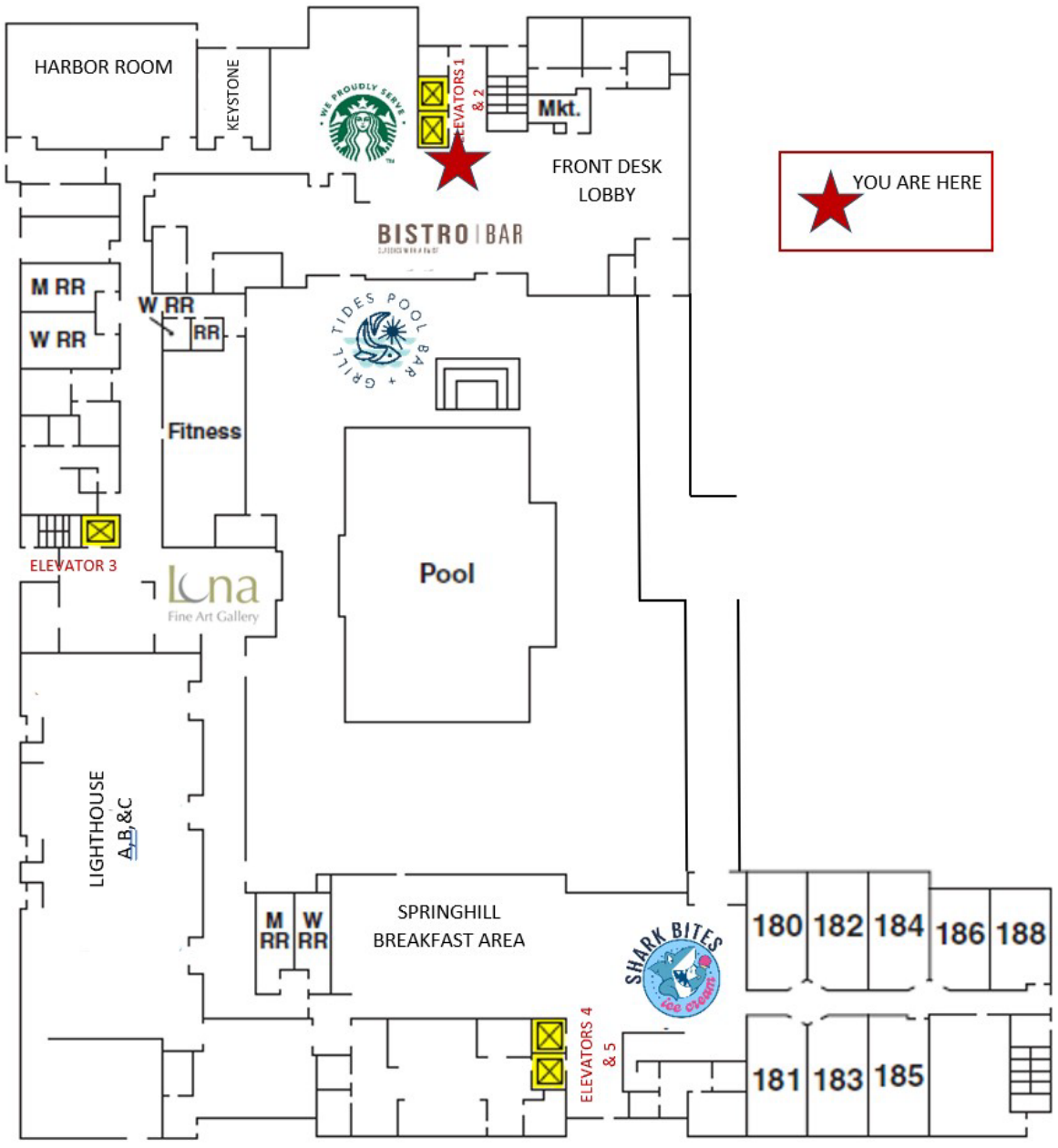
Accurate tree seedlings detection is essential for monitoring forest regeneration and supporting plantation management. Traditional field measurements are labor-intensive and error-prone, which creates a need for automated approaches. In this study, we compared two deep learning models: YOLOv8, a convolutional neural network (CNN), and D-FINE, a transformer-based detector for identifying 1 - 3 -year-old loblolly pine (Pinus taeda) seedlings from high-resolution Unmanned Aerial Vehicle (UAV) imagery. UAV flights were conducted over plantation stands in the Appomattox-Buckingham State Forest, Virginia. The dataset consists of 2268 RGB and 881 multispectral images that were annotated and divided into training, validation, and test sets. On RGB imagery, YOLOv8 achieved strong performance with a precision of 0.91, recall of 0.88, F1-score of 0.90, and mAP@0.5 of 0.95. D-FINE produced lower overall accuracy (mAP@0.5 = 0.83) but was more effective at localizing medium-sized seedlings. Both models performed less effectively on multispectral imagery compared with RGB. Overall, YOLOv8 showed higher accuracy making it well suited for seedling detection operation, while D-FINE offered advantages in bounding box refinements. These results highlight the tradeoffs between CNN and transformer-based architecture and demonstrate the potential of UAV based deep learning to enhance forest regeneration monitoring.

Hotel and Conference Center

Courtyard Amelia Island

2700-1 Atlantic Ave, Fernandina Beach, FL 32034

The event will be held in the Lighthouse and Harbor Rooms. Map is referenced to the lobby.



Other Information

Breakfast: We will be providing coffee and pastries each morning. If you would like a full breakfast, there are both on and offsite options available.

Lunch: Lunch will be provided each day. If you have dietary restrictions, please be sure to check with the even planner to ensure your needs are met.

Wi-Fi: Wireless internet is available. Please check with the venue for access information

Presentations: We would like to record presentations. If you would not like for your presentation to be recorded, please let Micky Allen know.

Boat Trip Instructions:

We will meet at 1 N Front St, Suite #3, Fernandina Beach, FL 32034 at 4:30. The boat leaves at 5:00, but people need to arrive earlier. Snacks and Beer will be provided on the boat. (of course, lots of Beer in a ship, what can go wrong?).

The starting point is a 5-minute drive from the Hotel, in historic Downtown Amelia, by the riverside.

Tell us how we did

We would love feedback on the event! Please take a few minutes to complete the survey by using the following QR code. This will be very helpful to continue improving future events.

Notes