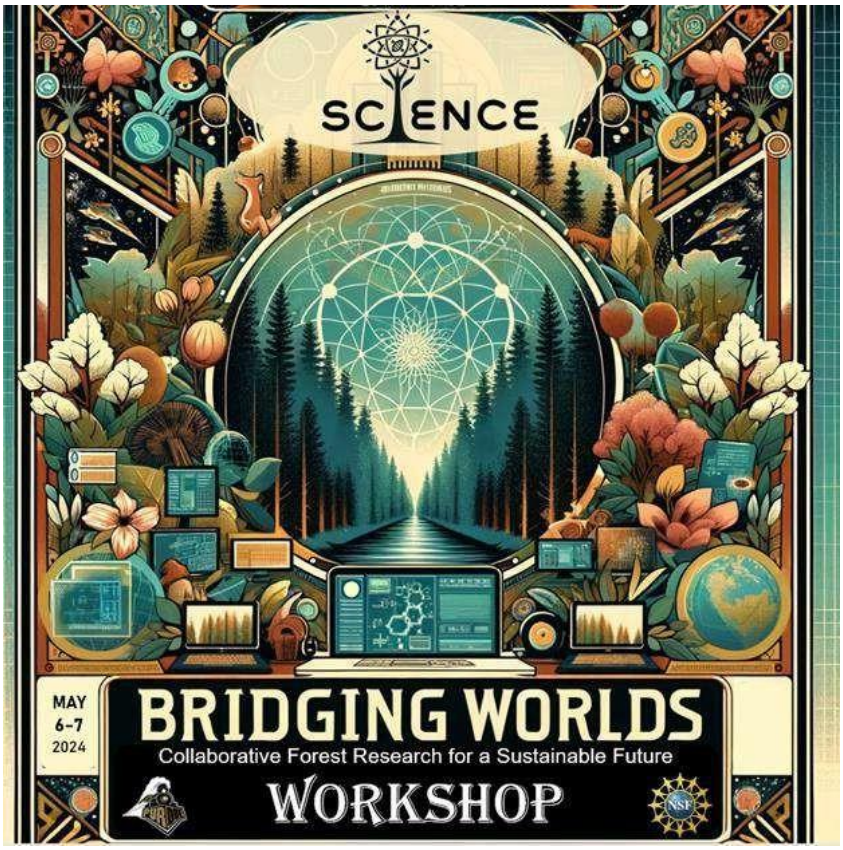
# Science-i Bridging Worlds Workshop Report

Science-i Support Team @ May 2024




## Executive Summary

Regenerating and conserving forests amid climate change is complex, hindered by the scarcity of data crucial for accurate land management models. To address this, Science-i was created as part of the Global Forest Biodiversity Initiative. Science-i hosts the largest global repository of forest inventory data, supported by experts dedicated to preserving wooded ecosystems. This platform safeguards and shares data for approved research, providing valuable insights. The Science-i team initiated the Global Big Ideas Competition and the Bridging Worlds Workshop to foster a community focused on forest management. Researchers worldwide submitted proposals, and 10 projects were selected by an expert panel. These projects received travel support through the Science-i NSF grant to participate in the workshop held on May 6-7 at Purdue University.

The workshop featured **70 participants from 22 countries**, and more than half of these participants are early-career researchers and students from the Global South and indigenous communities. The workshop also featured notable speakers, including world-renowned researchers, an editor from PNAS, a journalist from Mongabay, and representatives from the United Nations Food and Agriculture Organization (FAO), the National Indian Carbon Coalition, and the Central Africa Forest Observatory.

# Contents

## Goals of the Workshop

The Bridging Worlds Workshop convened with the primary goal of addressing the critical challenges confronting global forests amidst escalating climate change impacts and complex ecosystem interdependencies. Led by Dr. Liang and the Science-i team which is a part of the Global Forest Biodiversity Initiative, funded by the National Science Foundation (NSF grant no. 2311762), the workshop emphasized international collaboration, innovation, and the use of advanced technologies to drive impactful solutions.

The key objectives were to bridge data access gaps, advocate for sustainable forest management practices, and amplify the voices of marginalized communities, including indigenous groups. The workshop aimed to foster a community dedicated to the management and protection of global forests.

Strategic partnerships, access to advanced cyberinfrastructure, and a commitment to collaborative knowledge creation were central to the workshop's approach. This report provides an overview of the winning research ideas, summarizes the invited talks delivered during the workshop, outlines panel discussions, existing and potential collaborations, and highlights potential next steps for the activity.


Science-i Workshop Group Photo was taken on May 6th, 2024 – Day 1 of the workshop

The participants of the workshop successfully attained the overarching goals outlined, including advancing data accessibility, leveraging high-performance computing, generating impactful research outputs, empowering underrepresented communities, promoting sustainable practices, and building a global forest research community as highlighted in this report.

# Science-i Introduction

The welcome speech at the Science-i workshop was delivered by **Dr. Jingjing Liang** from Purdue University. The speech outlined the plan and expectations for the next two days including "Ecology's Diversity Gap - The Untold Global South Perspectives," aimed to bridge the gap between the "global north" and "global south" in ecology by addressing two key issues: the lack of data and computing power. He introduced the Science-i platform, emphasizing its focus on FAIR data principles and providing High-Performance Computing (HPC) access to researchers worldwide.


With over 400 members from 57 countries, including a majority from the global south, Science-i promotes customizable data sharing policies and collaboration tools. It boasts the world's largest biodiversity database and is home to the largest global forest research community. The workshop was planned to feature ten "Big-Idea" competition winners detailed in Appendix C of this report, who presented their groundbreaking research.

The overarching goal of the workshop was to organize efforts that would produce ten research manuscripts for publication, leveraging global data, international expertise, and world-class computing power. Attendees were encouraged to engage with Science-i, collaborate on ongoing projects, and make use of the resources provided by the US National Science Foundation (NSF), Purdue University, and Science-i itself. Overall, the welcome speech set the stage for a collaborative and impactful workshop, highlighting the importance of diversity, data accessibility, and cutting-edge technology in ecological research.

# Insights from Keynote Speakers

## Innovation in Forest Research Talks to Politics

**Javier Gamarra** from the Food and Agriculture Organization of the United Nations delivered a thought-provoking talk on "Innovation in Forest Research Talks to Politics." He highlighted the importance of promoting forestry through international platforms like the International Day of Forests, emphasizing the need to generate excitement and adopt a systems approach in research methodologies. Gamarra stressed the urgency of addressing ecological crises by advocating for an "ecological research war economy" and emphasized the increased demand for deployable solutions that support local communities. He underscored the significance of open data and inclusivity in data ownership, calling for action-oriented policies to meet these evolving societal demands.


During the presentation, he echoed Charles Krebs' insights, urging researchers to adopt a systems approach with explicit hypotheses, theoretical models, and large-scale field experiments tailored to specific ecological challenges. He discussed the growing collaborations in forest research, linking them intrinsically to the need for innovation. Gamarra outlined the urgent action policies sought by societies, including accurate monitoring of forests, addressing land use changes, carbon dynamics, biodiversity conservation, and supporting sustainable forest management for indigenous communities. He emphasized the importance of facilitating data access and interoperability while adhering to confidentiality and access rules, aligning with global initiatives such as the UN Decade for Restoration and frameworks like IPCC and IPBES.

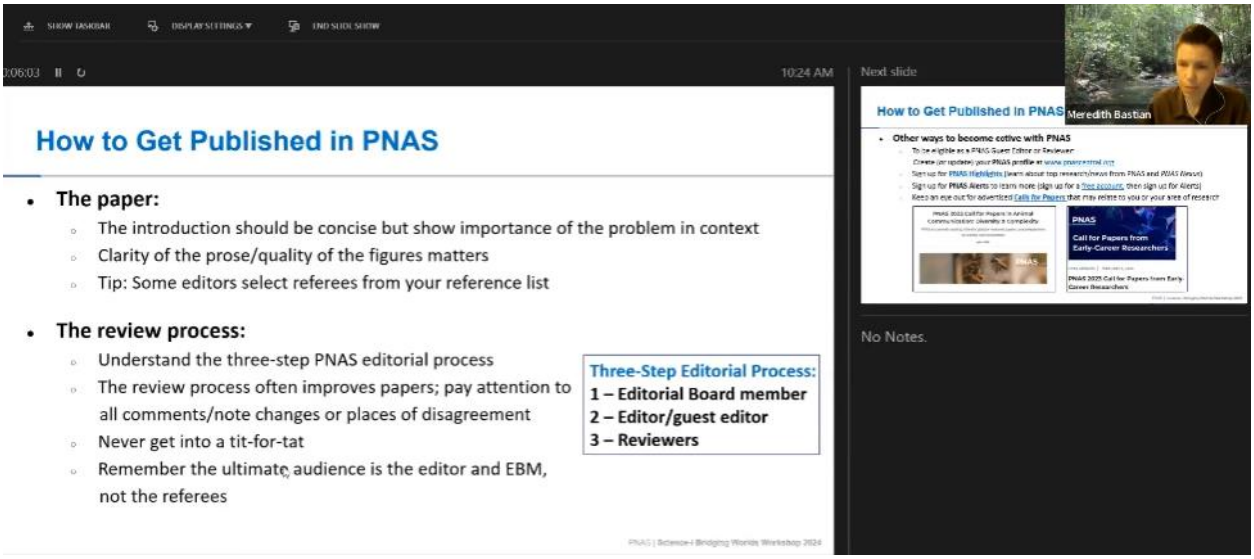
# Science Innovation from the Perspective of a Journalist

**Liz Kimbrough**, a staff writer at Mongabay with a background in botany and tree microbes, delivered an insightful talk titled "Beyond the Silo - Bringing Innovations to the Public." Kimbrough shared her perspective as a journalist focusing on science innovations and emphasized the critical role of science communication (SciComm) in informing and inspiring the public, influencing policy decisions, and building public trust. She outlined practical strategies for scientists and researchers to effectively communicate their work to the media, starting with writing a compelling press release targeted at relevant publications and ensuring timeliness, human interest, proximity, conflict, impact, and novelty in the content.


In her presentation, Kimbrough discussed the key elements of a successful press release, including audience considerations, active language without jargon, essential facts, quotes, visuals, and contact details for follow-ups. She highlighted the importance of pitching innovations to media organizations and provided resources such as The Open Notebook for successful story pitches, EurekaAlert for science press releases, SciLine for connecting researchers and journalists, and platforms like The Conversation for pop-science articles. Kimbrough encouraged researchers to support their content with graphics, follow-up with journalists, and utilize platforms like ComSciCon workshops and Mongabay submissions to effectively bring innovations to the public sphere.

## From Ideas to Publications

**Meredith Bastian**, a recruiting editor and member of the committee on Diversity, Equity, and Inclusion (DEI) at the Proceedings of the National Academy of Sciences (PNAS), delivered an insightful online presentation titled "From Ideas to Publications." Bastian provided an in-depth exploration of the intricate journey involved in translating scientific concepts into published articles, particularly focusing on the processes and opportunities available within the esteemed journal PNAS. She began by shedding light on the sheer volume of submissions received by PNAS, with over 20,000 submissions and 3,000 published articles in the year 2023 alone. This staggering statistic underscored the rigorous nature of the initial evaluation process conducted by the editorial board, which typically results in the rejection of approximately two-thirds of submissions deemed incompatible with the journal's criteria.




Throughout her presentation, Bastian underscored the essential elements crucial for a successful submission to PNAS. She emphasized the significance of framing research within the context of addressing critical scientific problems, advancing the boundaries of the respective field, and possessing broader implications or appeal across multiple disciplines. Bastian delved into the nuances of crafting compelling submissions, including the importance of attention-grabbing titles, well-crafted abstracts that encapsulate the essence of the research, and concise yet impactful introductions that establish the significance of the work within the broader scientific landscape. Additionally, she provided valuable insights into the collaborative review process at PNAS, which involves input from various stakeholders such as editorial board members, editors, guest editors, and reviewers. Bastian advised authors to approach reviewer feedback constructively, maintaining a dialogue focused on addressing concerns and enhancing the overall quality of the manuscript. She also highlighted PNAS's steadfast commitment to promoting diversity, equity, and inclusivity within the scientific community, showcasing initiatives such as equitable access for authors without publication funding, support for early-career researchers through workshops and special features issues, and opportunities for guest editorship. Furthermore, Bastian introduced PNAS Nexus as a complementary journal designed to cater to interdisciplinary and broadly impactful research, offering different article types and the option to transfer submissions from PNAS if they are better suited for Nexus. Overall, Bastian's comprehensive presentation provided invaluable guidance and insights for researchers navigating the intricate path from conceptualizing ideas to achieving successful publication outcomes.

## The Economic Way of Thinking for Ecologists and Conservationists

**Dr. Mo Zhou** from Purdue University delivered an enlightening talk titled "Economic Way of Thinking for Ecologists & Conservationists." Her presentation emphasized the paramount importance of embracing an economic mindset, even for those not specializing in economics, as it holds the potential to significantly impact ecological endeavors and optimize outcomes for conservation efforts. Central to her discourse was

the fundamental economic principle encapsulated by "TINSTAAFL" (There is no such thing as a free lunch), which underscores the idea that every decision or action carries a cost and involves trade-offs. This concept of opportunity cost, wherein individuals must consider what they are giving up obtaining what they desire, formed a cornerstone of her discussion.


Throughout the talk, she delved into various economic tools and frameworks that are applicable to ecological and conservation contexts. Concepts such as cost-benefit analysis and cost-effectiveness analysis were explored in depth, illuminating how these methodologies enable researchers and policymakers to quantitatively assess the benefits and costs of different actions or strategies. She also touched upon the concept of sustainability, distinguishing between strong and weak sustainability and prompting critical reflections on the substitutability of human capital for natural capital.

The practical application of economic thinking was exemplified through a compelling case study involving the northern spotted owl and the timber industry. This case study vividly showcased the intricate complexities and multifaceted considerations inherent in balancing ecological conservation with economic activities. Dr. Zhou underscored the pivotal role of public planning in making informed decisions that weigh future benefits and costs against present ones, advocating for a nuanced approach that considers both long-term ecological health and economic viability. By quantifying trade-offs and embracing a multi-objective perspective, her presentation underscored the necessity of meaningful discourse and informed decision-making in navigating the intricate intersections of ecology and economics.

## The promise and pitfalls of ’nature-based solutions’ to our climate crisis

**Dr. Peter Reich**, an online presenter from the University of Michigan and the University of Minnesota, delivered an insightful talk titled "Promise & Pitfalls of 'Nature-Based Solutions' to Climate Crisis." Despite technical difficulties causing his computer to go black during presentation mode, Dr. Reich provided a comprehensive guide on combatting climate change while enhancing social justice. He began by highlighting the critical state of Earth's biomes by the 2020s, emphasizing the urgency of protecting and restoring natural ecosystems, with a focus on trees and forests.


Dr. Reich's work centered on understanding the CO2 and plant ecosystem cycle, exploring how these systems can maintain functionality in the face of global change. He introduced the concept of "nature-based solutions" (NbS), which involve actions aimed at protecting, sustainably managing, and restoring natural functions to combat climate change. These solutions encompass a range of strategies such as decarbonizing electricity, electrifying various sectors, promoting energy efficiency, and enhancing carbon sequestration efforts. Dr. Reich underscored the interconnectedness of sustainability goals, emphasizing that climate action is a linchpin (#13) without which the others cannot be achieved.

The talk delved into the fundamentals of the carbon cycle, explaining global carbon sources, sinks, transfers, and the significant role of terrestrial ecosystems in sequestering carbon. Dr. Reich highlighted the enormous potential of optimizing land use and restoring forests to mitigate climate change impacts, citing studies that show even minor improvements in carbon acquisition by land sources can yield substantial benefits. He also discussed lesser-known NbS strategies like utilizing tree-based materials in construction, promoting plant-rich diets, and implementing low-input agriculture methods. However, Dr. Reich didn't shy away from addressing the potential pitfalls and challenges associated with NbS, including social justice concerns, the effectiveness of certain solutions, and the economic implications of inaction. Overall, Dr. Reich's talk urged for concerted efforts to leverage nature-based solutions while posing the crucial question of whether humanity will prioritize its long-term self-interest in combating climate change.

## Nature-Based Solutions on Indigenous Land

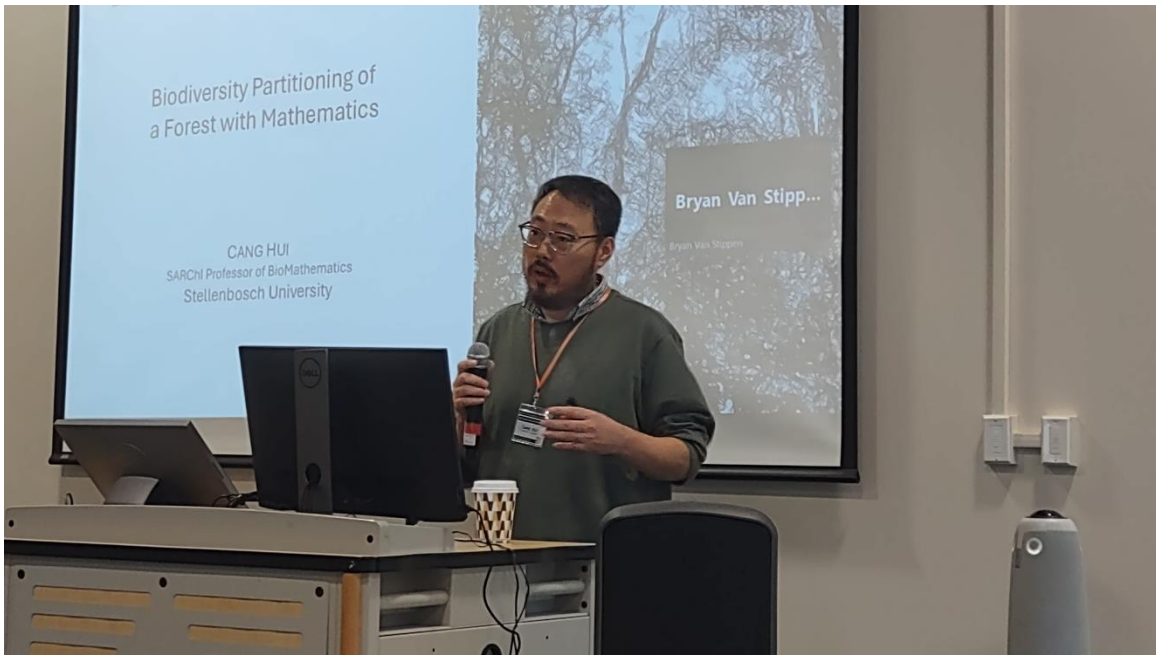
**Dr. Bryan Van Stippen**, representing the National Indian Carbon Coalition (NICC) in an online presentation, delivered an enlightening talk on "Nature-Based Solutions on Indigenous Land." Dr. Van Stippen began by introducing NICC, a non-profit organization formed by the Indian Land Tenure Foundation and the Intertribal Agriculture Council. The primary goal of NICC is to assist tribal nations and tribal landowners in leveraging carbon credit programs to generate additional revenue and promote land stewardship. Dr. Van Stippen highlighted the historical context, noting that tribal members have often faced pressure to exploit

natural resources like timber and oil for income generation. However, with modern schemes such as carbon credits, there is a new opportunity for tribal nations to capture value from their land while preserving it and improving environmental health.


The talk focused on NICC's primary activities, which include working closely with tribal members to navigate new markets and choose suitable partners, providing unbiased data and evaluations using web mapping and satellite imagery, offering education and guidance on carbon sequestration and management, and assisting tribes throughout the inventory, planning, credit sales, and monitoring phases of carbon projects. Dr. Van Stippen emphasized the importance of responsible carbon credit sales through the Tribal Land Conservation Initiative, ensuring that partnerships are aligned with tribal values and do not benefit polluters or contribute to irresponsible practices. NICC acts as a broker in the market for tribal entities, covering upfront capital costs and working with third-party consultants on behalf of tribes. The credits are not sold for less than $10 per credit, and tribal entities have a say in selecting organizations to purchase the credits. The presentation concluded with an overview of ongoing projects with tribes such as Fon de Lac, Keweenaw Bay, and the Mississippi Band of Choctaw, showcasing the tangible impact of nature-based solutions on Indigenous lands.

## Biodiversity Partitioning of a Forest with Mathematics

**Dr. Cang Hui** from Stellenbosch University delivered an enlightening talk titled "Biodiversity Partitioning of a Forest with Mathematics." In his presentation, Dr. Hui explored the intrinsic value of biodiversity, tracing the evolution of woody plants over millions of years and emphasizing Earth's long history as a "woody" planet. He focused on the Diepwalle Afrotemperate Forest, delving into its historical significance, including early Dutch colonial activities related to timber and subsequent legislative measures to preserve the forest's integrity.

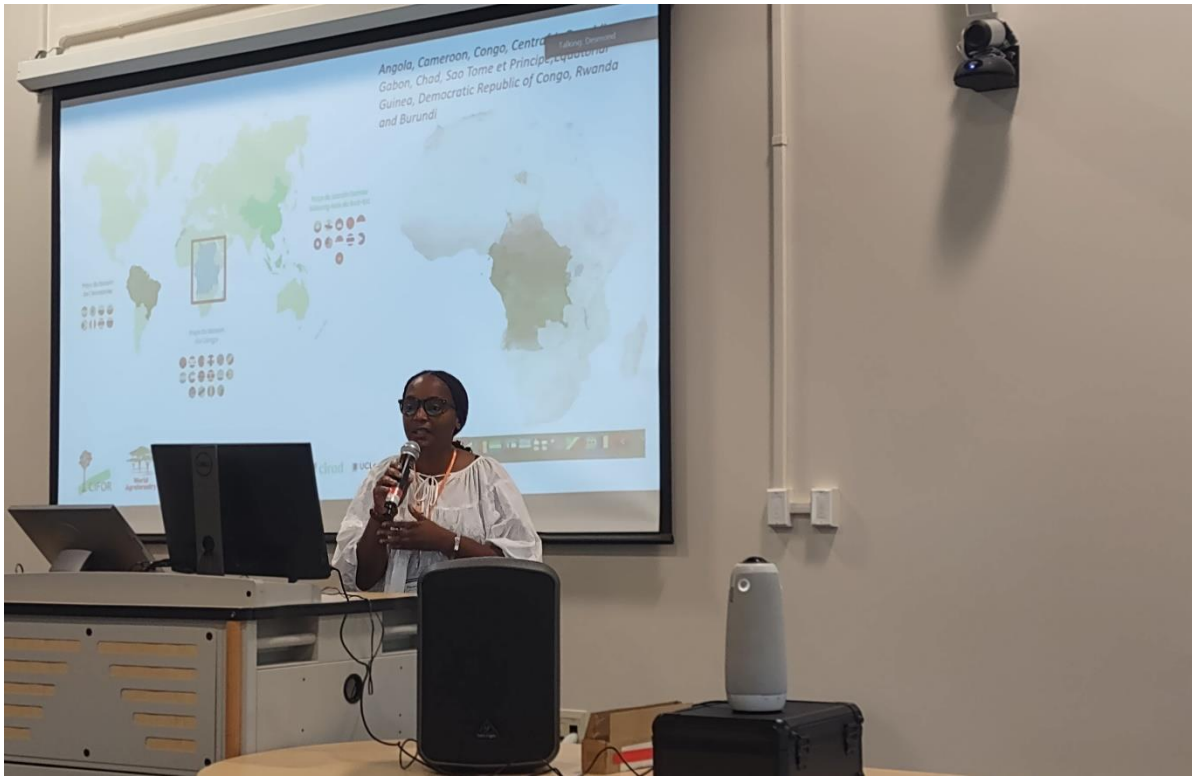



Utilizing mathematical tools such as Venn diagrams and binary vectors, Dr. Hui discussed spatial partitioning techniques to understand biodiversity distribution within the forest. He demonstrated how dividing the forest into multiple components and analyzing overlap patterns among species can reveal insights into endemic species' occupancy and shared regions. Dr. Hui also explored the complexities of integrating additional trait-based matrices to tackle the "4th corner problem" and gain a deeper understanding of biodiversity dynamics.

Throughout the talk, Dr. Hui showcased the practical applications of mathematical frameworks in ecological research. He discussed studying behaviors of native versus alien species, investigating insect population decline through projects like GLITRS, and exploring niche-based biodiversity using distance decay plots and accumulation versus turnover analyses. Dr. Hui's work hinted at the potential for a unified theory of biodiversity, highlighting the importance of mathematical modeling in unraveling complex ecological phenomena and informing effective conservation strategies.

## Biodiversity Conservation in Africa

**Dr. Florence Palla**, the Coordinator of the RIOFAC project at the Central African Forest Observatory in Cameroon, delivered an insightful presentation titled "Biodiversity Conservation in Africa." In her talk, Dr. Palla provided a detailed overview of conservation efforts in Central Africa, focusing particularly on the immense ecological significance of the Congo Basin. This vast region encompasses 270 million hectares of land, constituting 70% of Africa's forests and harboring an extraordinary diversity of life including 10,000 plant species, 400 tree species, and 1,400 animal species. These forests play a vital role in supporting the livelihoods of about 75 million people in the region.




During her presentation, Dr. Palla traced the historical trajectory of biodiversity conservation in Africa, highlighting the transition from colonial-era protected areas that primarily focused on specific species to a more integrated approach in the 21st century. This modern approach involves establishing a network of protected areas across African nations and actively engaging local communities in governance structures. Despite challenges posed by development activities conflicting with conservation objectives, significant strides have been made in creating terrestrial and marine protected areas and addressing threats from extractive industries.

Dr. Palla emphasized the ongoing challenges facing biodiversity conservation in Central Africa, including biodiversity loss, habitat destruction, emerging diseases, climate change impacts, and wildlife trade. She also discussed various initiatives such as the CARPE and ECOFAC programs, which have promoted landscape-level conservation planning and coordinated regional conservation efforts. Additionally, Dr. Palla underscored the importance of effective governance, capacity-building, and the recognition of Other Effective Zone-Based Conservation Measures (OECMs) like sacred forests in achieving long-term conservation objectives. She also stressed the need for improved research methodologies, increased contributions from central African authors, and enhanced accessibility of scientific knowledge for informed conservation management.

# Panel Discussion: Introduction to Science-i Data Resources & Cyberinfrastructure

**Moderator: Dr. Jingjing Liang**

The panel discussion, moderated by Dr. Jingjing Liang, aimed to delve into the intricacies of data collection, utilization, and challenges faced in various scientific endeavors. The panel featured distinguished experts who presented their insights and experiences in different areas related to data science and biodiversity conservation.

## Introduction to Science-I Cyberinfrastructure

*Speaker: Rajesh Kalyanam, Purdue RCAC*

Rajesh Kalyanam's presentation on Science-I Cyberinfrastructure delved into the intricate processes involved in managing and utilizing data for scientific research. He outlined a systematic workflow starting from data request submission to eventual publication, highlighting the importance of collaboration and streamlined processes. The emphasis was on creating an ecosystem where researchers can contribute their data, have it processed and integrated into a centralized repository, and then access it for analysis and further collaboration. Rajesh showcased the planned deployment of the Science-I cyberinfrastructure on the MyGeoHub science gateway as a pivotal platform for data management, analysis, and collaboration, showcasing its existing features and the anticipated impact on scientific research outcomes.

Additionally, Rajesh showcased the capabilities of Anvil, an NSF-funded Category 1 supercomputer local to Purdue, in supporting resource-intensive computations, data processing, and model simulations. Rajesh's presentation not only provided insights into the technical aspects of data handling but also underscored the collaborative and interdisciplinary nature of modern scientific research, where cyberinfrastructure plays a crucial role in facilitating data-driven discoveries and insights.

## Global AI Augmented Biodiversity Database [GAIA-BD]

*Speaker: Wookjin Choi, Purdue FACAI Lab*

Wookjin Choi's presentation on GAIA-BD offered a comprehensive overview of the database's objectives, methodologies, and potential impact on biodiversity conservation efforts. He discussed the challenges posed by data accessibility and the prevalence of incidence datasets over abundance datasets, emphasizing the need for a comprehensive and georeferenced database like GAIA-BD. Wookjin highlighted the database's unique features, including its hierarchical global grid system, integration of community characteristics and environmental data, and inclusion of both abundance and incidental datasets from terrestrial ecosystems worldwide. He provided detailed insights into the vast amount of data within GAIA-BD, showcasing its coverage across continents, countries, and ecosystems, and its potential to inform evidence-based conservation strategies and policies.

Moreover, Wookjin emphasized the role of AI and machine learning in augmenting biodiversity research, showcasing how GAIA-BD leverages advanced technologies to process and analyze massive datasets. He discussed the significance of the database in advancing scientific research, enhancing biodiversity monitoring efforts, and promoting global collaboration among researchers and conservationists. Wookjin's presentation shed light on the complexities of biodiversity data management and the potential of AI-driven databases like GAIA-BD in addressing critical conservation challenges and fostering a deeper understanding of global biodiversity patterns.

## Forest Monitoring Network in Mexico

*Speaker: María Guadalupe Nava-Miranda, University of Santiago de Compostela, Spain*

María Guadalupe Nava-Miranda's presentation focused on the Forest Monitoring Network in Mexico, providing a detailed overview of the project's objectives, methodologies, and outcomes. She highlighted the importance of long-term data collection and monitoring in forest ecosystems, especially in regions like Mexico with rich biodiversity and diverse forest types. Maria discussed the various components of the Monafor Platform, including data generation, submission, database management, and science studies derived from curated data. She emphasized the continuous generation of field data since 2007 and the growing importance of integrating new technologies to streamline data collection, processing, and analysis.

Furthermore, Maria elaborated on the challenges and opportunities associated with forest resource quantification using the Conafor platform, showcasing the platform's capabilities in supporting different plot designs and enabling robust data-driven decision-making in forestry management. She discussed the need for financial resources, data audit, platform updates, and the exploration of new technologies to enhance data collection efficiency and accuracy. Maria's presentation underscored the critical role of long-term monitoring networks like Monafor in cataloging forest dynamics, supporting scientific research, and informing sustainable forest management practices in Mexico and beyond.

### Studying growth in Natural Forests Under Scarce Data - A Call for Better Modelling

*Speaker: Christian Salas-Eljatib, Universidad de Chile*

Christian Salas-Eljatib's presentation delved into the challenges and opportunities associated with studying growth in natural forests, particularly in the context of limited data availability. He emphasized the invaluable role of natural forests in ecosystem stability, biodiversity conservation, and climate change mitigation, contrasting them with forestry plantations often targeted for commercial purposes. Christian discussed the limitations of current modeling approaches and the need for better quantitative tools to understand and predict forest dynamics accurately.

Moreover, Christian highlighted the complexities of data collection in natural forest ecosystems, including the lack of long-term datasets, unreliable weather station records, and the need for standardized protocols in sample plot design. He underscored the importance of integrating both physiological-based and hybrid modeling approaches to capture the nuances of natural forest growth, emphasizing the trade-offs between mathematics and statistics in ecological modeling. Christian's presentation advocated for a holistic approach to forest research, promoting long-term data collection, experimental studies, and improved modeling techniques to bridge the gap between theory and practice in natural forest management and conservation.

## “Big-Ideas” Presentations Overview

### ZetaForests: Unravelling Global Forests Turnover and Co-Occurrence

**Dr. Sanda MacFayden**, a researcher from Stellenbosch University, presented a comprehensive online research talk on ZetaForests, focusing on unraveling the higher-order turnover and co-occurrence of global forest diversity. The presentation delved into the utilization of advanced methodologies like MS-GDM (Multi-Site Generalized Dissimilarity Modeling) and zeta diversity metrics to understand the significance of environmental gradients and spatial distance in explaining species assembly turnover within forests.

The talk commenced by outlining the objectives of the research, which included a deep dive into the mechanisms behind species turnover and co-occurrence in forests globally. Dr. MacFayden detailed the structured methodology involved in the study, spanning data collection, model crafting using MS-GDM and zeta diversity metrics, analysis, dashboard development, synthesis of findings, and eventual

publication. This systematic approach aimed to provide a holistic understanding of how species turnover is influenced by environmental factors and spatial distances across different forest sites.

Throughout the presentation, Dr. MacFayden elucidated various diversity metrics essential for the research, such as alpha diversity, gamma diversity, beta diversity, and the central focus on zeta diversity. By introducing the concept of orders of Zeta, she explained how these metrics describe the number of distinct taxa across different numbers of sites, offering valuable insights into the turnover patterns between forest locations. The application of MS-GDM to zeta diversity was highlighted as a significant advancement, enabling a more nuanced analysis of species turnover relative to environmental gradients and zeta diversity levels.

Moreover, Dr. MacFayden provided practical examples, such as the dragonfly analogy, to illustrate how zeta values reflect turnover mechanisms driven by rare versus widespread species within forest ecosystems. The talk concluded with a discussion on the Zeta-Distance Decay concept, emphasizing its role in understanding how species sharing changes with increasing distances between forest sites and its implications for environmental filtering. Overall, Dr. MacFayden's research presentation shed light on cutting-edge methodologies and insights crucial for unraveling complex patterns of forest biodiversity and turnover at a global scale.

## Adapting Trees: Ecological Strategies in a Changing Climate

**Gabrial Yan Rosa**, from FURB, Brazil presented an insightful online talk titled "Adapting Trees - Ecological Strategies in a Changing Climate," focusing on the FlorestaSC project in Santa Catarina, Brazil. The presentation began by outlining the diverse forest types in the region, including evergreen rainforests, araucaria forests, and semi-deciduous forests, each characterized by unique species compositions and ecological dynamics. The FlorestaSC project, spanning over 16 years of systematic inventory work since 2007, has been instrumental in cataloging over 3000 vascular plant species using the IFN-BR methodology, with data collected in cycles approximately every seven years.

One of the central challenges highlighted in the talk was the classification of ecological strategies within the plant species, based on Grime's CSR framework. The competitive (C), stress-tolerant (S), and ruderal (R) strategies represent distinct ecological responses to environmental conditions. By analyzing functional attributes such as leaf area, specific leaf area, and leaf dry matter content across a diverse range of specimens and localities, the research delved into understanding the distribution and prevalence of these ecological strategies within Santa Catarina's forests.

The talk also discussed advanced modeling techniques like Joint Species Distribution Modeling (JSDM) and Hierarchical Modeling of Species Community (HMSC), which provided insights into how environmental and biotic factors influence species distribution and community dynamics. Looking towards the future, the research aims to integrate socio-economic pathways (SSPs) and bioclimatic variables to predict potential changes in Santa Catarina's forests by 2055. This forward-looking approach seeks to identify which ecological groups may benefit or be harmed, as well as the overall trends in forest dynamics, whether they are gaining or losing in response to climate shifts. His talk highlighted the interdisciplinary nature of forest ecology research and its importance in understanding and adapting to environmental changes.

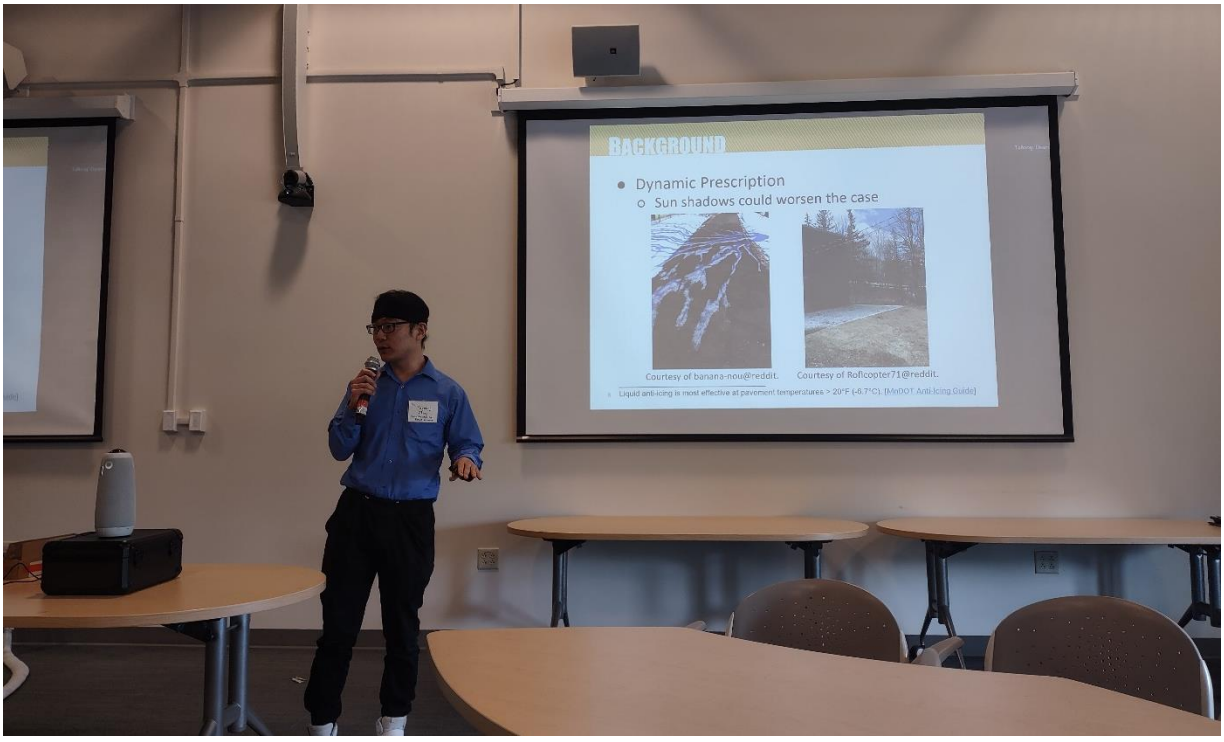
## Forestry Remote Sensing Data Analysis using Quantum Edge Detection

**Vivian Sattler** from Leibniz University Hanover delivered a thought-provoking online presentation titled "Forestry Remote Sensing Data Analysis Using Quantum Edge Detection," delving into the cutting-edge realm of quantum computation and its potential applications in image processing, particularly in forestry remote sensing. The talk commenced with an overview of quantum computation, tracing its origins to the theoretical groundwork laid by Richard Feynman in the 1980s. Quantum computing harnesses the principles of quantum mechanics, utilizing qubits (quantum bits) with unique properties like superposition states and entanglement, leading to exponential speedups compared to classical computing in certain tasks.

Sattler highlighted the current state of quantum computers, noting the challenges posed by environmental noise and the limitations in qubit capacities despite ongoing advancements. The presentation then delved into the concept of edge detection in image processing, a computationally intensive task traditionally handled by classical computing methods. The introduction of Quantum Hadamard Edge Detection (QHED) presented a revolutionary approach, demonstrating exceptional speed and efficiency with a complexity that scales as O(1), making it significantly faster than classical methods.
The application of QHED to forestry remote sensing data was exemplified through a case study using data from Jeju Island in South Korea. The preprocessing involved contrast enhancement, grayscale conversion, and manual georeferencing, followed by quality assessment against Google Maps satellite data. The results showed promising capabilities in detecting human-made infrastructure and street features, although there were instances of false positives due to shadows, outlier trees, and cloud cover. Sattler concluded by discussing the potential avenues for further research, including exploring other QHED variants, running experiments on real quantum hardware, and extending the application of quantum methods to address broader forestry challenges. The talk shed light on the transformative potential of quantum computation in advancing remote sensing and data analysis techniques in forestry management.

## Automating Large-Scale Site-Specific Solar Resource Maps

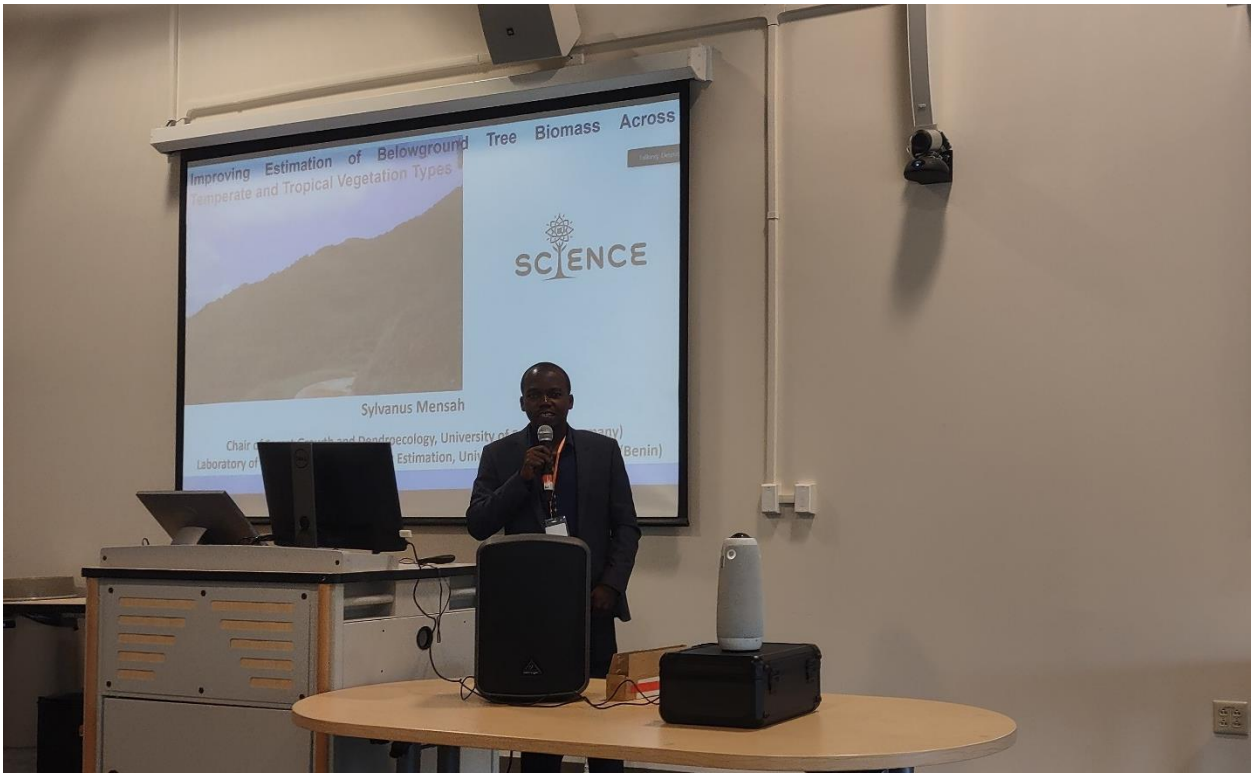
**Dr. Yaguang Zhang**, a researcher from Purdue University, presented a detailed overview of the automation of large-scale site-specific solar resource maps during a research talk. The focus of the discussion was on the practical applications of this technology, particularly in managing snow and ice on roads, a critical aspect of transportation infrastructure. Dr. Zhang highlighted the challenges faced during winter conditions, including reduced transportation efficiency and safety hazards for drivers, which necessitate effective winter roadway treatments like plowing and de-icing.



The research effort, spanning several years from 2016 to 2022, involved a collaborative initiative to create a Digital Surface Map (DSM) for the state of Indiana using LiDAR data collected by Purdue University. Dr. Zhang discussed the sophisticated simulation process developed to calculate direct-path blockages on roadways caused by sun shadows, emphasizing the significance of accurate solar position calculations using the Solar Position Algorithm (SPA) developed by NREL. The simulation methodology was meticulously designed, involving breaking down the area of interest and road network into grid points, which were then processed using high-performance computing (HPC) clusters.

A key aspect of Dr. Zhang's presentation was the validation of the simulation results through comparisons with real camera observations, ensuring the accuracy and reliability of the solar resource maps generated. The practical implications of this research for transportation management, especially for organizations like the Indiana Department of Transportation (INDOT), were underscored. Dr. Zhang outlined the development of a user-friendly frontend interface that would enable INDOT users to input road names, allowing the simulator to identify and simulate road segments in parallel. This innovative approach has the potential to revolutionize road segment management by optimizing resource allocation for de-icing and enhancing overall road safety during winter conditions.

## Estimation of Belowground Tree Biomass Across Temperate and Tropical Vegetation Types




**Dr. Sylvanus Mensah**, a researcher from the University of Freiburg, delved into the complexities of improving the estimation of belowground tree biomass across temperate and tropical vegetation types during his research talk. He began by sharing his introduction to Science-I, mentioning how he discovered

the platform in 2022 on ResearchGate and was impressed by the engagement and support he received from Dr. Jingjing Liang. Dr. Mensah expressed gratitude for the opportunity to be part of a community that brings together leaders and researchers from diverse regions.

The talk transitioned to Dr. Mensah's ongoing research projects, highlighting the significance of biomass estimation in various ecosystems such as western African coast mangroves and tree savannahs. He emphasized the critical role of forest carbon stocks in climate policies, particularly in the context of global warming, carbon credits, and initiatives like REDD+ (Reducing Emissions from Deforestation and Forest Degradation). Dr. Mensah discussed the challenges in accurately measuring aboveground and belowground carbon pools, noting that while litter and soil are relatively easier to measure, estimating tree biomass accurately often requires destructive methods, which can be costly and site-specific.

One of the key aspects of Dr. Mensah's presentation was his research project for the Science-I competition, aimed at developing an improved analytical tool for accounting and monitoring belowground biomass across diverse environments. He outlined the methodology, including compiling worldwide datasets on belowground biomass, tree diameter, height, and wood density from published literature. Dr. Mensah discussed the process of extracting numerical data from published plots using tools like WebplotDigitizer and incorporating environmental factors like longitude, latitude, climate seasonality, and soil information to enhance accuracy. The timeline for the project's completion, set at 18 months starting in July 2024, was also mentioned, indicating a comprehensive and systematic approach to address the research gap in belowground biomass estimation.

## Resolution Effects on Modelling Net Primary Production in Global Terrestrial Ecosystems

**Dr. Xiaolu Tang** from Chengdu University of Technology led an insightful online research talk focusing on the impact of resolution on modeling Net Primary Production (NPP) in global terrestrial ecosystems. Tang initiated the discussion by drawing attention to the current state of the climate, highlighting the notable increase in global temperatures since 1880, which has resulted in a warming of 1.66 degrees Celsius and a substantial carbon increase of 10 petagrams (Pg). Emphasizing the crucial role of vegetation as a significant carbon reservoir, Tang underscored its importance in global carbon sequestration efforts. Key statistics such as the global forest Aboveground Carbon (AGC) ranging from 426 to 572 Pg C and China's Forest Aboveground Biomass (AGB) from 7 to 21 Pg C were cited, illustrating the magnitude of carbon storage in vegetation.

The online talk delved into the intricacies and challenges associated with accurately estimating Net Primary Production (NPP), discussing various methodologies including field measurements, modeling, and data-driven approaches. Tang highlighted persistent challenges stemming from knowledge gaps in size and patterns, uncertainties in field measurements, sampling sizes, model accuracy, model approaches, and spatial resolutions. An important scientific inquiry posed by Tang revolved around the optimal resolution to be used—fine or coarse—and the computational costs associated with each, given the necessity to predict NPP across different resolutions ranging from 0.05 to 0.5 degrees. Tang referenced

several prominent databases such as Grower, CFCCD, SRDB, ForC, Fluxnet, and Luyssaert, outlining the criteria for data selection, which prioritized field observations, excluded modeling data, and required at least one year of disturbance-free observations. The talk also introduced the application of Random Forest, a nonparametric modeling technique leveraging statistical analysis, to rank environmental variables and validate NPP predictions using methods like 10-fold cross-validation, year removal, or site removal.

## Wrap-Up and Future Steps

### *Moderator: Dr. Jingjing Liang*

The moderator, Dr. Jingjing Liang, summarized the goals achieved during the workshop, highlighting the ten big ideas that emerged, leading to the anticipated development of ten co-produced research manuscripts powered by global data, international expertise, and advanced computing capabilities in a prestigious journal such as PNAS. The focus then shifted towards the next steps envisioned for the participants, including creating a new project within Science-I, inviting collaborators to join, and providing regular updates on findings. Additionally, attendees were encouraged to schedule one-on-one meetings with the Science-I support team to discuss data needs and register for access to the high-performance computing (HPC) resources on Anvil.


## Exploring Resources and Collaborations

During the general discussions, participants raised various queries and suggestions. They discussed tutorials and resources for HPC, introduction to Machine Learning and AI, formulating research questions for top journals, and writing effectively for publication. Moreover, connections between international and indigenous communities were explored. Dr. Liang and other experts provided insights and guidance on these topics, offering avenues for further exploration and collaboration within the Science-I framework.

## Project-Specific Discussions:

### *1.1.1. ZetaForests: Unravelling global forests turnover and co-occurrence*

The ZetaForests team primarily discussed challenges related to datasets and potential solutions through online tools. They expressed excitement about accessing Science-I data and HPC resources, emphasizing the need for more interesting covariates in their data analysis. Additionally, they highlighted the importance of genus-level data and phylogenetic trees for their research. Dr. Liang assured them of possible data conversions and provided insights into HPC usage, data availability, and potential collaborations for enhancing their project's scope and accuracy.

### *1.1.2. Automating Large-Scale Site-Specific Solar Resource Maps*

The Solar Resource Maps team focused on extending their support area and improving computational efficiency. They discussed challenges with LiDAR data quality and data storage issues, particularly when scaling to a global level. Discussions also revolved around rewriting code for better performance and exploring alternative data sources for studying specific ecological aspects impacted by solar coverage. Collaborative suggestions were made regarding utilizing Purdue's resources, expertise, and infrastructures for improving their modeling and data analysis techniques.

### *1.1.3. Improving estimation of belowground tree biomass across temperate and tropical vegetation types*

The Belowground Biomass Quantification team highlighted their need for datasets and integration strategies. They discussed challenges related to accurately estimating belowground biomass and the importance of robust data sources for their global dataset. Collaboration possibilities were explored,

including sharing datasets, leveraging existing models, and incorporating advanced data analysis techniques. Suggestions were made regarding potential data sources and methods for estimating biomass belowground, including soil organic carbon measurements.

### *1.1.4. Adapting Trees: Ecological Strategies in a Changing Climate*

The Adapting Trees team identified computational power as a key limitation for their project. They discussed the complexity of their models, including occurrence data, co-variances, and trace data relationships, necessitating advanced computational resources. Collaborative opportunities were explored, including leveraging GFBI data, utilizing HPC resources, and collaborating with other organizations to enhance their carbon intake modeling and forest adaptation studies.

### *1.1.5. Forestry Remote Sensing Data Analysis using Quantum Edge Detection*

The Quantum Computing Edge Detection team discussed their progress in proving the efficacy of their approach and the need for algorithm improvements. They explored potential pre-processing steps to eliminate data inaccuracies, such as cloud cover interference. Collaborative suggestions were made regarding benchmarking quantum computing results against traditional AI algorithms and utilizing Purdue's resources for enhancing their data analysis techniques and model accuracy.

### *6.2.6 Amazon Basin Pristine Forest Mapping*

The Amazon Basin Pristine Forest Mapping team shared their efforts in mapping forest integrity and environmental impacts using machine learning and remote sensing techniques. They discussed challenges related to data attributes, such as tree species data and forest integrity metrics. Collaborative discussions

focused on leveraging Purdue's resources, expertise, and datasets for refining their models, analyzing environmental features, and assessing the impacts of human activities on forest ecosystems.

## Collaborative Opportunities

Dr. Liang emphasized collaborative opportunities within Science-I, highlighting the platform's potential for data sharing, collaboration, and project development. He encouraged participants to leverage available resources and engage in ongoing communication and collaboration through Science-I. The workshop concluded with acknowledgments to funding sources and organizers, expressing gratitude for the transformative discussions and initiatives that emerged during the event. Participants were encouraged to stay connected and explore avenues for continued collaboration and research advancement.

## Campus Tour

After the insightful and engaging discussions that took place on day 2 of the workshop, Dr. Liang graciously organized a comprehensive campus tour at Purdue University's West Lafayette campus. This tour provided a valuable opportunity for the speakers and participants to explore the university's facilities, immerse themselves in the academic environment, and further network with each other. The tour included visits to key academic buildings, research facilities, and notable landmarks on campus, offering participants a deeper understanding of Purdue University's commitment to research, innovation, and academic excellence.

# Field Trip

Following the conclusion of the workshop, Dr. Jingjing Liang organized an optional field trip to Turkey Run State Park at Lafayette the day after the workshop. Participants enjoyed a scenic hike, exploring the park's

biodiversity and ecological significance. The outing provided a refreshing break and an opportunity to appreciate the natural beauty of the area as well as the geological and physiographic drivers of biodiversity in central hardwood forests.


Field Trip Photo was taken at Turkey Run State Park on May 8th, 2024

Following the hike, the group had lunch in Indianapolis. This relaxed setting allowed for further discussions and networking among the attendees, fostering informal connections and collaboration opportunities beyond the formal workshop environment.

# Appendix A: Workshop Organizers, Acknowledgments and Agenda

## Organizing Committee

- Dr. Jingjing Liang
- Jennifer L Spitznagle
- Heather Dawson
- Desmond Sosu Mensah
- Ankita Mitra
- Wookjin Choi
- Varsha Raj Basavaraja
- Mustak Ahmed

## Acknowledgments


- NSF (award #2311762)
- Purdue Institute for Sustainable Future
- Purdue Institute for Physical AI
- Purdue Rosen Center for Advanced Computing
- Purdue Department of Forestry and Natural Resources


## Agenda

### Sunday, May 5, 2024

**6:00 PM - 8:45 PM**

Location: PMU Hail Purdue Room.

*The shuttle will wait outside the hotel entrance from 5:20pm to 5:40pm.*

Ice-Breaking Reception

*Featuring gourmet refreshments and live music by the West Lafayette Trio*

### Monday, May 6, 2024

**8:00 AM - 9:00 AM**

Location: Atrium, Purdue Hall for Discovery and Learning Research (DLR).

*The shuttle will wait outside the hotel entrance from 7:20am to 7:40am.*

Continental Breakfast

**9:00 AM - 9:45 AM**

Location: DLR131

Welcome and Overview

- Jingjing Liang, FACAI Lab, Purdue University, USA
- Javier Gamarra, FAO (online presentation)

Moderator

- Ankita Mitra, FACAI Lab, Purdue University, USA

**9:45 AM – 11:00 AM**

Location: DLR131

**Invited Talks**

- Science Innovation from the Perspective of a Journalist - Liz Kimbrough, Mongabay
- From Ideas to Publications - Meredith Bastian, PNAS (online presentation)

**11:00 AM - 11:15 AM**

Location: DLR131

Break and Refreshments

**11:15 AM - 12:30 PM**

Location: DLR131

**Invited Talks**

- The Economic Way of Thinking for Ecologists and Conservationists - Mo Zhou, FACAI Lab, Purdue University, USA
- The promise and pitfalls of 'nature-based solutions' to our climate crisis – Peter Reich, University of Michigan & University of Minnesota, USA

**12:30 PM - 1:30 PM**

Location: Atrium

**Luncheon and networking**

Travel reimbursement session with Jennifer Spitznagle

**1:30 PM - 3:00 PM**

Location: DLR131

**Research Talks** (20 minutes talk each + 10 minutes Q&A)

- ZetaForests: Unravelling Global Forests Turnover and Co-Occurrence - Sandra MacFadyen, Stellenbosch University, South Africa
- Adapting Trees: Ecological Strategies in a Changing Climate - Gabriel Yan Rosa, FURB, Universidade Regional de Blumenau, Brazil
- Forestry Remote Sensing Data Analysis using Quantum Edge Detection - Vivian Sattler, Leibniz University Hannover, Germany

**3:00 PM - 3:30 PM**

Location: DLR131

Break and Refreshments

**3:30 PM - 5:00 PM**

Location: DLR131

**Panel Discussion**

- Introduction to *Science-i* Data Resources and Cyberinfrastructure

Panelists:
- Rajesh Kalyanam, Purdue University, USA
- Wookjin Choi, FACAI Lab, Purdue University, USA
- María Guadalupe Nava-Miranda, University of Santiago de Compostela, Spain
- Christian Salas-Eljatib, Universidad de Chile, Chile

Moderator:
- Jingjing Liang, FACAI Lab, Purdue University, USA

**5:30 PM - 7:00 PM**

Location: Atrium

Themed Dinner with live music by the *West Lafayette Trio*

## Tuesday, May 7, 2024

**8:00 AM - 9:00 AM**

Location: Atrium

*The shuttle will wait outside the hotel entrance from 7:20am to 7:40am.*

Continental Breakfast

**9:00 AM - 10:30 AM**

Location: DLR131

**Invited Talks**

- Nature-Based Solutions on Indigenous Land - Bryan Van Stippen, National Indian Carbon Coalition, USA (online)
- Biodiversity Partitioning of a Forest with Mathematics - Cang Hui, Stellenbosch University, South Africa
- Biodiversity Conservation in Africa - Florence Palla, Central African Forest Observatory, Cameroon

**10:30 AM - 10:45 AM**

Location: DLR131

Break and Refreshments

**10:45 AM - 12:15 PM**

Location: DLR131

**Research Talks** (20 minutes talk each + 10 minutes Q&A)

- Automating Large-Scale Site-Specific Solar Resource Maps - Yaguang Zhang, Purdue University, USA
- Improving Estimation of Belowground Tree Biomass Across Temperate and Tropical Vegetation Types - Sylvanus Mensah, University of Freiburg, Germany
- Resolution Effects on Modelling Net Primary Production in Global Terrestrial Ecosystems - Xiaolu Tang, Chengdu University of Technology, China (online)

**12:15 PM - 1:30 PM**

Location: Atrium

Luncheon with Topic Tables

**1:30 PM - 3:00 PM**

Location: DLR131

Workshop Wrap-Up and Forward Look

- Summary of Key Insights
- Discussion on Collaborative Opportunities and Next Steps

**3:30 PM - 5:00 PM** (Optional)

Purdue Campus Tour

**5:00 PM**

Workshop adjourns

# Appendix B: Workshop Participants

## In-Person Participants

| No. | Name | Main Affiliation | Email |
|---|---|---|---|
| 1 | Adebola Esther Adeniji | Purdue University | adeniji@purdue.edu |
| 2 | Alex Mehne | Fond du Lac Reservation | alexandermehne@fdlrez.com |
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| 17 | Finnan White | West Lafayette Trio (WLT) | |
| 18 | Florence Palla | "RIOFAC support OFAC Project" | fpalla@observatoire-comifac.net |
| 19 | Gabriel Yan Rosa | FURB | gabriel.yanr@gmail.com |
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| | | | |
|---|---|---|---|
| 27 | Liz Kimbrough | Mongabay | lizkimbrough@gmail.com |
| 28 | Luhanhai Ying | Purdue University | ying48@purdue.edu |
| 29 | María Guadalupe Nava-Miranda | Universidad de Santiago de Compostela USC / Universidad JuÃ¡rez del Estado de Durango UJED | nava.miranda@gmail.com |
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## Online Participants

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|---|---|---|---|
| 1 | Ajay Singh | Wildlife Institute of India | ajsingh248@gmail.com |
| 2 | Bryan Van Stippen | National Indian Carbon Coalition | bvanstippen@iltf.org |
| 3 | David Salzgeber | Mydataplanet.com SaaS | david@oneplanet-solutions.com |
| 4 | Dmitry Schepaschenko | IIASA | schepd@iiasa.ac.at |
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| | | | |
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| 22 | Xiaolu Tang | Chengdu University of Technology | lxtt2010@163.com |

# Appendix C: 10 Big Ideas Competition Winners

| | Title | Name | Country | Email |
|---|---|---|---|---|
| 1 | ZetaForests: Unravelling global forests turnover and co-occurrence | MacFadyen, Sandra | South Africa | sandra@biogis.co.za |
| 2 | Adapting Trees: Ecological Strategies in a Changing Climate | Rosa, Gabriel Y. | Brazil | gabriel.yanr@gmail.com |
| 3 | Automating Large-Scale Site-Specific Solar Resource Maps | Zhang, Yaguang | USA | ygzhang@purdue.edu |
| 4 | Phylogenetic diversity-productivity relationships at the global scale | Huang, Erhan | China | huangerh@stu.pku.edu.cn |
| 5 | Improving estimation of belowground tree biomass across temperate and tropical vegetation types | Mensah, Sylvanus | Benin | sylvanus.m89@gmail.com |
| 6 | Prioritizing Forest Cover Restoration Opportunities in West Africa: Strategies for Natural Regeneration, Agroforestry, and Plantation | Amani Bienvenu Hippolyte Konan | Côte d'Ivoire | bienvenuh.amani@gmail.com |
| 7 | Compare the carbon storage of urban forests with natural forests | He, Chenqi | China | chuckiey_email@stu.pku.edu.cn |
| 8 | Safeguarding high integrity tropical forests using translational science | Vilanova, Emilio, J. | Venezuela | evilanova@wcs.org |
| 9 | Multiple disturbances impact on West African tree species abondance | Zo-Bi, Irie, C. | Côte d'Ivoire | casimir.zo@inphb.ci |
| 10 | Forestry Remote Sensing Data Analysis using Quantum Edge Detection | Vivian Sattler | Germany | vsattler@purdue.edu |

# Appendix D: Workshop Future Steps Discussions

ZetaForest

- The first of the challenges we face is the dataset. I am excited to get access to the Science-I data just learning about from this workshop.
- Excited to access your HPC power we don't have back home.
- The idea of making things an online tool is exciting. We've done some prototypes and AWS dashboards, so exploring more options will be good.
- What kind of variables can we have in the data? We want to study more interesting co-variates.
- It would be nice to get data of a genus-level, a phylogenetic tree for all species. It would be very helpful. For the implementation, we would probably have to do that at a sequential level. Work our way towards this level of specificity.
- *Dr Liang: Regarding the data, our new version of the data we can look into converting it to what you want. With the HPC, once you sign-up with the form shared yesterday, you will have access to explore. There is a learning curve to using the HPC. It is not like a remote desktop; it involves learning the Linux version of the code and the methods for submission. We can help you with that. The most available data for our team, there are several different categories. We also have the future predicted data and the tomography data, 9 or 10 datasets of them. We also have global soil data. The others will take time. The phylogenetic trees would be great to have.*
- *Rajesh: For the compute, the portfolio of NSF compute is not just the Anvil cluster here at Purdue. There are other machines around the country in a big network, like Pittsburgh has a cluster with nodes that have 4TB of RAM. We can help you find the best venue. The R Shiny app you mentioned, we can do that as part of the MyGeoHub infrastructure on the new Science-I website, but we can also run things like that on Anvil.*
- Do you have any limitations on what we should use?
- *Rajesh: Just to deploy it, R Shiny is probably easier, but if you have Google Earth key we can do that. It doesn't really matter what you want to use. There are some apps that are already supported and integrated, and others we would have to explore.*
- Through this Horizon Europe project, it requires all data products to be licensed a certain way. Are there any issues with Science-I and this?
- *Dr Liang: The only thing that we require is plot-level data is shared with the community, but any product you create is your property and we make no license requirements on it.*

Solar Resource Maps

- Soon we want to extend the support area beyond just Indiana, and we learned there is a new dataset called 3DP provided by GIS. After that, our next step is that if we want to extend to whole globe, we don't know how to get good quality LiDAR data for that.
- We are thinking we could begin running maps for selected areas that are already prepared for people to browse as pre-computed.

- Working on getting a student funded to rewrite code away from Matlab. For example, currently our code is CPU parallel but not GPU parallel.
- For storage, based on just Indiana, after compression is still 300GB+ of data. If dataset is like that for whole of United States, would be 10s of TB.
- *Dr Liang: WIth regard to the LiDAR data, we use some of them, but there may be better ways to find height elevations. Your idea of finding the sun shadow and quantifying them is good, and you should start thinking of new products to use this.*
- *Cang: So, in the conventional models, the solar coverage data is not good enough for studying some specials like reptiles and insects.*
- *Sandra: Does that data have to be LiDAR? Because we have things like cloud coverage data that could impact. Is that useful to you?*
- Good point. We have been looking around for other data sources, but for each dataset we have to write a new translator for formatting. We chose to use LiDAR from USGS because it was standard across the whole state, only need to write one data translator. So it is doable.

<u>Belowground Biomass Quantification</u>

- We are looking to develop contact with anyone who has possible datasets we can use. The second challenge is how we are planning to incorporate integration of different datasets, to correct for issues.
- We are trying at the end of it, to have global dataset that can be posted somewhere and can be incorporated into some sort of package or database component for other models.
- *Dr. Liang: I want to commend you for taking on this challenging topic. When the GFBI got started, we also needed to aggressively get global data for trees. We were doing this at an NSF workshop in West Virginia, and we listened to the proposed research ideas, and we heard the challenges for global data. My feedback from the program director, some of them laughed at our idea, in 2016, but we were able to get all the data we needed within a year to get started. I want to encourage you, is always a challenge, but it is something you can get done. We are here to help you, if you are determined. With regard to spatial correlation, there was a paper with a tool on this, we can point you at it.*
- *Christian: Spatial correlation depends on the model you are using, but if you want to make inference on co-variates, that is another level of challenging task.*
- *Rajesh: I don't know how many papers you plan to run the web digitizer to pull numbers from papers, but if you want help to try to automate that, we can try to help with our HPC.*
- *Dr Liang: We have been trying with some of Ankita's work to digitize some numbers on biomass we might be able to help share.*
- *Ankita: Are you planning to use the root-to-shoot ratios?*
- We are limited by always needing the aboveground biomass to get the belowground biomass, so we need some way to accurately estimate the aboveground biomass for the belowground parameters.

- *Wisconsin: You might want to look at the tree stump removal data. Fon De Lac reservation would definitely be interested in belowground biomass for decomposing soil properties. There might be ways you could estimate biomass belowground by measuring soil organic carbon.*
- *Sandra: There's a contact in Germany who has similar work I can provide for you that might have some advice on this topic.*

Adapting Trees

- The main limitation with the project will be the computation power. As I was studying the scene of people already using it, it would seem to need a very powerful computer or cluster of computers to run the models. Not only are we using the occurrence data, but also the co-variances and trace data and relationship between all that. HSMC cannot run large simulations and we are open to collaborations with other organizations. We want to study how the carbon intake of the forest is changing.
- *Dr Liang: This is a great topic. I think our GFBI data can be useful for you and will be available. We do have species data. Lots of studies have been using this data. And we have the HPC available for you to use, and we encourage it.*
- Yes, we try the database and we limit it to our region. We are also comparing a computation tool based on the area that we try. Would be great to have other biomes around the world to try to create a more precise model.
- *Mensah: yesterday in your presentation you mention that you couldn't incorporate the phylogenetic information in the data and that at greater scale you could try to incorporate this. Definitely there is an opportunity to exploit these in the ?? data.*
- So, yes, we could use the phylogenetic data but we didn't put it in the project yet because of the data availability for our state. We didnt know so we had to go with what we had reliable. We need to have more than just a trace for it to be possibility, so we prove as most as possible.

Quantum Computing Edge Detection

- So far we have just been trying to prove it works, and now we can work on improvements now that we have shown first results. We will work on the algorithm and also work on improving the data. For example, I showed how the cloud cover can impact the data. Perhaps there is a pre-processing step to eliminate that from the data. Perhaps our work now is very specific coding problems, so grateful to hear your opinion.
- *Dr Liang: I think good to do would be to find the reference date to compare your findings to other methods. Maybe on plan is to show results using quantum computer versus some sort of AI algorithms.*
- *Sandra: We have very large dataset using traditional machine learning to map the veins instead the wings, and be interested to see how it would do with your data.*
- *Cang: For many of us, we don't quite understand the quantum computing and how exactly you are using it compared to traditional neural networks. We are able to train on 2000 source images and then we can quickly identify wing mappings with great pixel accuracy, within 1 or 2 pixels. So*

*not quite sure yet what the advantage of quantum computing for this is over conventional approaches.*

- Yes, there is also a quantum machine learning that might be possibility to explore. And comparing all of these approaches to see which is best.
- *Dr Liang: Also, the quantum edge detection is impacted by the algorithm chosen. So results will change as it is improved. There is possibility to greatly speedup as data size increases and algorithm improves.*
- *We study the wing "landmarks" to find the morphologies. We have 2000 training images, but perhaps the GFBI ground data can be already tagged and suitable for use as training data.*
- *Sanda: Our machine learning use case uses a lot of shape and color to identify things like invasive species within larger aerial photographs.*
- Perhaps we could use your training data to save on the manual pre-processing steps
- *Cang: If you can develop your program to detect urban boundaries, there are lots of studies that need this kind of capability. Hard to define what we mean by urban boundaries that want to study urban growth.*
- *Liang: Perhaps there are applications for helping also with another project Purdue has to detect forest camouflage edges.*
- *Rajesh: There is another group at Purdue that is using 100 GPUs to study 300 cities from satellite imaging to do something similar. Would like to see a comparison.*

Amazon Basin Pristine Forest Mapping

- We are working as quickly as possible to find solution, very similar to human footprint index applied to forest landscape. In 2020, first map published. Now there is a team working on a time series of this map. Tricky to quantify, on a spectrum of low to high integrity. There are many gaps. We are launching an initiative to find the most pristine forests. Scientifically where we want to test is where there are many important features like carbon and biodiversity. Studying the Amazon basis. For now not sure if we will be using the GFBI plot data. We want to use those datasets in a machine learning approach to analyze all those datasets for two main models: (1) what are the environmental features, (2) how much can this model improve when the human pressure is on forest? So for now we still playing around with datasets and tools. Hope to get an idea for what we can do with this. We want the countries who will use this to ve able to say we have this proportion covered by this type of forest, this area has this percentage of carbon, etc.
- *Dr Liang: Regarding the type of data you need, for biodiversity, do you think the tree species as an attribute would be useful?*
- For the 2020 paper I used the species data from the raster file scaled to the same resolution you used. I'm still not sure if I want to use it. My coworkers think if it is not accounting for where the forests are, it is not useful. I do hope I could explain those relationships, how it interrelates with the species and carbon. Now we want to put it all in a more complex model and compare it to the integrity of the forest. When I talk about the integrity, I mean, how does it compare to the pristine nature, away from nodes, away from the edge effects of human activity.

- *Dr. Liang: Yeah, we would like to help you.*
- **How can we follow the different projects to be involved, how to follow-up from this event?**
- Going back to the graph of the proposed Science-I data flow, you are all data contributors and users. We want to build these processes to capture these efforts in different projects in Science-I where you can all interact and collaborate. We want to enable you to invite contributors to your projects through Science-I.
- We potentially already have more ideas being developed among the audience here, and we want to have a platform for science communication and collaboration.
- Lindsey: I'm a science writer with Purdue, and I want to tell you to reach out to the communications office at your institutions to help you get the word out about your projects.

# Appendix E: Workshop Speakers and Panelists

## Meredith Bastian

Dr. Meredith L. Bastian is a Recruiting Editor at the Proceedings of the National Academy of Sciences (PNAS) and the research advisor to the Orangutan SSP (Species Survival Plan). She earned her PhD in 2008 from Duke University in Biological Anthropology and Anatomy and has worked with numerous species of nonhuman primates in various capacities over the past 25 years, including 8 years of fieldwork with wild Bornean orangutans and gibbons in Southeast Asia and 11 years as a zoo primate curator. Meredith has over 30 publications in PNAS, Nature, and various disciplinary journals and remains active in the orangutan research and conservation communities. She has been at PNAS since early 2021 and in her role as a Recruiting Editor and current chair of the journal's Committee on DEI (Diversity, Equity, and Inclusion), Meredith works closely with NAS member scientists and other subject matter experts throughout the biological, social, and physical sciences to recruit papers with a focus on increasing opportunities and exposure for underrepresented areas and authors.

**Talk:** From Ideas to Publications

## Wook Jin Choi

Wook Jin Choi is currently a PhD student of FACAI Lab, in the Department of Forestry and Natural Resources at Purdue University. He completed his Master of Arts degree in Latin American Economics in 2021 at Hankuk University of Foreign Studies in South Korea, where he also earned a bachelors of science in Bioscience and Biotechnology and a bachelors in Spanish Interpretation and Translation in 2016. His research focuses on the relationship between global change and forest ecosystem diversity, utilizing big data and artificial intelligence. Choi has published several papers on topics ranging from deforestation in Latin America to the effects of corruption on CO2 emissions in South America.

**Panelist**: Science-i Data Resources and Cyberinfrastructure

## Javier G. P. Gamarra

Dr. Javier Gamarra is an International Consultant in Forest Statistics at the Food and Agriculture Organization of the United Nations (FAO). Gamarra is a seasoned academic with a deep specialization in Theoretical Ecology and Epidemiology, as well as expertise in spatial scaling and complex systems. Originating from Spain, Javier has cultivated an extensive career in academia, holding positions at notable institutions such as Aberystwyth University in the UK. He has a rich background in environmental systems, contributing to research that integrates field data with numerical models to better understand ecological and hydrobiological processes. His academic journey is marked by a PhD in Nonlinear Dynamics and Control in Ecosystems from the University of Lleida and Polytechnic University of Catalonia, reinforcing his strong foundation in forest science and ecosystem dynamics. Javier's research has not only advanced theoretical frameworks in ecology but also practical applications in environmental management and conservation.

**Talk:** Welcome and overview

## Cang Hui

Dr. Cang Hui is a professor of mathematical biology and holds the South African Research Chair in Mathematical and Theoretical Physical Biosciences at Stellenbosch University. He is a trustee of the International Initiative for Theoretical Ecology. He has published widely on biological invasions and ecological networks, including three authored books, Invasion Dynamics (Oxford University Press), Ecological and Evolutionary Modelling (Springer), and Invading Ecological Networks (Cambridge University Press).

**Talk**: Biodiversity Partitioning of a Forest with Mathematics

## Liz Kimbrough

Liz Kimbrough is a staff journalist for the non-profit conservation news site Mongabay. She has written about science and environmental issues for over a decade and holds a PhD in Ecology and Evolutionary Biology from Tulane University where she studied the microbiomes of trees.

**Talk**: Science Innovation from the Perspective of a Journalist

## Rajesh Kalyanam

Dr. Rajesh Kalyanam is a Senior Research Scientist in the Rosen Center for Advanced Computing at Purdue University. He leads and works on federally funded projects at the intersection of advanced computing and science and engineering. He has over 15 years of experience as a full stack application developer and has worked on science gateway projects in cybersecurity, geosciences, anthropology, and communications. He is currently the Co-PI of the National Science Foundation funded Anvil supercomputer deployed at Purdue University and the Co-PI of the Science-I project, responsible for the cyberinfrastructure design.

**Panelist**: Introduction to Cyberinfrastructure Support

## Jingjing Liang

Dr. Jingjing Liang is an esteemed scholar in the field of Quantitative Forest Ecology. Dr. Liang's dedication to advancing forest science is further demonstrated through his founding of Science-i, a pioneering research metaverse, and his leadership as the Leading Coordinator of the Global Forest Biodiversity Initiative. Dr. Liang has a remarkable record of scholarly publications, including contributions to high-impact journals like Nature and Science. A recipient of numerous accolades, Dr. Liang has been recognized for his contributions to forest ecology and his innovative approach to integrating AI and big data in environmental research. His leadership in professional organizations and editorial contributions to esteemed journals underscore his standing as a thought leader and advocate for sustainable forest management practices worldwide.

**Talk**: General Introduction and Summary

## Sandra MacFadyen

Dr. Sandra MacFadyen is a post-doctoral research fellow at Stellenbosch University's Mathematical Biosciences Lab (BioMath) within the Department of Mathematical Sciences. With over 25 years of experience in protected areas research, gained from more than 15 years of service at South African National Parks, Sandra brings valuable insights to the BioMath team. Sandra's research primarily focuses on macroscale ecosystem dynamics, with a special emphasis on applied spatiotemporal statistics for biodiversity monitoring. She is intrigued by the intricate interactions between environmental drivers and responders, striving to understand how these dynamics shape and sustain landscape patterns and ecological processes. Sandra believes that this understanding is crucial for the longevity of protected ecosystems, guiding her work towards creating effective, efficient, and economical tools for tracking macroscale biodiversity patterns and trends, especially in large, protected areas.

**Talk**: ZetaForests: Unravelling Global Forests Turnover and Co-Occurrence

## Sylvanus Mensah

Dr. Sylvanus Mensah (Beninese) is currently a research fellow in the Chair of Forest Growth and Dendroecology at Albert-Ludwigs-Universität Freiburg, Germany. He is also a research associate in the Laboratory of Biomathematics and Forest Estimation at the University of Abomey Calavi, Benin. He obtained his doctorate degree in Forestry from Stellenbosch University (South Africa), and has 10 years of research experience in the fields of forest ecology and biometry. His research spans various scales, from individual to community levels, with specific focus on tree growth and biomass modelling as well as biodiversity and ecosystem functioning. He makes use of observational data from local, regional and global scales to explain how forest ecosystem functioning responds to environmental variations and human interactions. In the last five years, Sylvanus has developed a particular interest in ecological mechanisms underlying forest ecosystem functioning in changing climate.

**Talk**: Improving Estimation of Belowground Tree Biomass Across Temperate and Tropical Vegetation Types

## Ankita Mitra

Ankita Mitra is currently a PhD scholar in Quantitative Forest Ecology at Purdue University, with a focus on forest modeling using machine learning models. In addition to her research, she actively supports the Science-i platform. Ankita has accrued over six years of research experience in forest ecology, conducting studies in the Smithsonian Tropical Research Institute of Panama and in the coastal mangrove forests of the Indian Sundarbans. Ankita earned her Bachelors in Environmental Sciences from the University of Calcutta in India and received silver medal for her academic achievements. She pursued her masters of science degree from Pondicherry Central University in India, and received Gold Medal from the Governor in 2016 for her outstanding performance. Post-Masters, she enhanced her expertise in several industrial based EIA-research projects at the Indian Institute of Technology in West Bengal and the CSIR-central government research institute in Gujarat, India. Throughout her career, prestigious fellowships such as the US-Israel Binational Science Foundation Fellowship and the Department of Science and Technology INSPIRE Fellowship have recognized her contributions.

**Workshop Moderator**

## María Guadalupe Nava-Miranda

María Nava-Miranda has training as a computer technician and forestry engineer specialized in forest inventories and biometry of natural ecosystems. She has been around for a decade as research assistant in the geomatics laboratory at the University Juarez of Durango State (UJED) mainly on feeding the database of permanent plots in Mexico with accurate observations also caring biodiversity aspects to develop spatial and temporal models essential for making decisions about natural resources. Specialist in Geographic Information Systems (GIS) and database management in the forestry sector in the UK-PACT Ecometric Project 2021 CONAFOR-PRONATURA SUR A.C., supporting the creation of database management protocols and GIS management for the study of mitigation scenarios and a general analysis of increases and loss in biomass. Currently she is PhD student in rural and civil developments at the University of Santiago de Compostela.

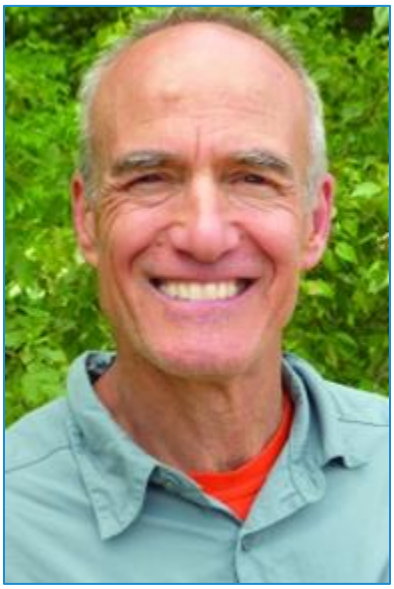
**Panelist**: Science-i Data Resources and Cyberinfrastructure

## Florence Palla

Dr. Florence Palla studied botany, then the environment, and specialized in nature conservation when she started working in the field in the Dja Biosphere Reserve in Cameroon. She holds a PhD in ecology from the University Pierre et Marie Curie (Paris VI). She contributed to the establishment and management of the Central African Protected Areas Network (RAPAC) by acquiring regional and international skills to support institutions and services in charge of protected areas. Since 2015, she has been coordinating the activities of the technical unit of the regional project (RIOFAC) supporting the Central African Forest Observatory (OFAC), including the observation of national and transboundary protected areas. She joined IUCN in 2014 as a member of the World Commission on Protected Areas (WCPA) and worked with different thematic groups to contribute to the realisation of IUCN's global vision to adapt it to the context of the Central and West Africa region.

**Topic**: Biodiversity Conservation in Africa

## Peter B. Reich



Dr. Peter Reich, a renowned expert in forest ecology, has been named Director of the Institute for Global Change Biology (IGCB) at University of Michigan. Reich, who has conducted global change research on plants, soils, and ecosystems across a range of scales, will maintain a joint affiliation at the University of Minnesota (UMN), where he is a Regents Professor, Distinguished McKnight University Professor, and the F.B. Hubacheck Sr. Chair in Forest Ecology and Tree Physiology. In addition to his work at UMN, Reich was the Chief Scientist at the Hawkesbury Institute for the Environment at Western Sydney University in Australia from 2011 to 2021. He is a member of the National Academy of Sciences of the United States and the American Academy of Arts and Sciences, a fellow of the Ecological Society of America, and a BBVA Prize Laureate (BBVA Foundation Frontiers of Knowledge Award in Ecology and Conservation Biology). He also helped launch the science education channel, MinuteEarth, which has more than 400 million views on YouTube and other platforms.

**Talk**: The promise and pitfalls of 'nature-based solutions' to our climate crisis

## Gabriel Yan Rosa

Gabriel Yan Rosa is a biologist graduated from the Universidade Regional de Blumenau (FURB) in Biological Sciences. Currently, he is pursuing a master's degree in Biodiversity at the Universidade Regional de Blumenau (PPGBio FURB), being a master's scholarship recipient from the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq). Gabriel is part of the team at the Dr. Roberto Miguel Klein Herbarium at FURB, assisting with laboratory demands. In his master's project, he studies the ecological strategies of tree species and communities and how they can be affected by climate change, aiming to generate models to assess changes in communities in the future. To achieve this, he collaborates with the FlorestaSC project, utilizing the database of measurements cycles conducted over the last 17 years. In previous projects, he worked with ecology and species distribution modeling. Gabriel has interests in the field of plant ecology, especially in tree communities, aiming to study the effects of climate change on these communities.

**Talk:** Adapting Trees: Ecological Strategies in a Changing Climate

## Christian Salas-Eljatib

Christian Salas-Eljatib, is a Full Professor of Forest Biometrics and Modelling at the Faculty of Forest Science and Nature Conservation at the Universidad de Chile, in Santiago, Chile. He holds a PhD in Biometrics (Yale University, USA), a masters degree in Statistics (University of Idaho, USA), and a bachelors degree in Forestry (Universidad de La Frontera, Chile). Christian research interests deal with developing mathematical and statistical models for forecasting forest ecosystem features, study tree allometry, and assessing sampling strategies.

**Panelist**: Science-i Data Resources and Cyberinfrastructure

## Vivian Sattler

Vivian Sattler is a master's student of physics at the Leibniz University Hannover, Germany. Within the scope of her bachelor's degree, her research focused on the theoretical analysis of quantum algorithms. She is currently enrolled at Purdue University as an international exchange student and has been introduced to forestry by participating in Professor Liang's class on Big Data analysis in forestry. Vivian is passionate about building bridges between research fields and strongly believes that interdisciplinary work is crucial for groundbreaking scientific developments. Hence, she is looking forward to presenting her work which started out as a class project and has evolved into an intriguing collaborative research endeavor at the intersection of quantum computation and forestry.

**Talk:** Forestry Remote Sensing Data Analysis using Quantum Edge Detection

## Xiaolu Tang

Dr. Xiaolu Tang is a professor at Chengdu University of Technology. He got his PhD degree in Gottingen University majoring forest ecology in 2015, then he continued to his postdoc research in Max-Planck Institute of Biogeochemistry in Jena, Germany. Now he mainly works on carbon cycling using field measurements, data-driven and global vegetation dynamic models, with a special focus on soil carbon cycling. With more than 10 years experiences, he is intrigued by the interactions between soil carbon fluxes and environmental drivers, striving understand how climate change and human activities affect soil carbon fluxes, and how temporal and spatial scales affect vegetation production at global scales.

**Talk**: Resolution Effects on Modelling Net Primary Production in Global Terrestrial Ecosystems

## Bryan Van Stippen

Dr. Bryan Van Stippen is Program Director for National Indian Carbon Coalition, an initiative of the Indian Land Tenure Foundation (ILTF) that provides education, training, and technical assistance to American Indian tribes, Alaska Native Villages & Corporations, Native Hawaiian organizations and First Nations in Canada on the development of carbon credit and renewable energy projects on tribal land. A member of the Oneida Nation of Wisconsin, Van Stippen previously served for seven years as Tribal Attorney for the Ho-Chunk Nation Department of Justice in Wisconsin where he was responsible for land acquisition and other land-related issues. He earned a bachelor's degree in Business Administration and a Masters in Computer Information Systems from Tarleton State University in Texas. Van Stippen is a graduate of the University of North Dakota School of Law (J.D.); the University of Tulsa College of Law (LL.M. in American Indian and Indigenous Law); and the University of Arizona James E. Rogers College of Law (S.J.D in Indigenous Peoples Law & Policy). He lives with his wife and two children in Green Bay, Wisconsin.

**Talk**: Nature-Based Solutions on Indigenous Land

## Yaguang Zhang

Dr. Yaguang Zhang is a Clinical Assistant Professor at Purdue University in the Department of Agricultural & Biological Engineering (ABE) and the Department of Agricultural Sciences Education & Communication (ASEC). He earned his PhD and master's degree in Electrical and Computer Engineering from Purdue University in 2021 and 2015, respectively, and his bachelor of engineering degree in Communication Engineering from Tianjin University in 2013. He recently completed a postdoctoral research position in the School of Electrical and Computer Engineering at Purdue University from 2021 to 2023.

**Talk**: Automating Large-Scale Site-Specific Solar Resource Maps

## Mo Zhou

Dr. Zhou's primary research interests at present are 1) integrating economic theory and data science to value nonmarket goods in forests and derive landowners' preferences and their interactions; 2) optimal decision making in forest management under risk and uncertainty induced by climate change; 3) economics of forest biodiversity at large scale; 4) dynamics of timber market and trade of forest products. Dr. Zhou was previously an Assistant Professor of Forest Economics at West Virginia University and before that an Assistant Professor of Economics at the University of Alaska Fairbanks. She has a bachelor of science degree in Information Sciences in Forestry from Beijing Forestry University, a master's degree in Forestry from the Technical University of Munich, and a PhD from the University of Wisconsin – Madison. Dr. Mo Zhou is the co-director of the Forest Advanced Computing & Artificial Intelligence (FACAI) Lab.

**Talk**: The Economic Way of Thinking for Ecologists and Conservationists

## The Forest Advanced Computing and Artificial Intelligence (FACAI) Laboratory

FACAI employs the paradigm of Artificial Intelligence (AI) encompassing different state-of-the-art machine learning and statistical methods to study global, regional, and local forest resource management and biodiversity conservation. FACAI stands at the forefront of integrating advanced computing and AI techniques into forest ecosystem studies. This lab is distinguished not only by its prowess in technology but also by its robust global partnerships, which enhance both data collection and research outcomes. FACAI operates with a unique asset—a comprehensive in situ forest inventory database spanning multiple continents. This allows them to back Science-i, a pioneering global research metaverse aimed at facilitating scientific innovation across disciplines. By striving for research outcomes that are both globally consistent and locally relevant, FACAI makes a significant contribution to the field of forestry and environmental science.

FACAI has significantly contributed to forest ecosystem studies, particularly through its connection with the Global Forest Biodiversity Initiative (GFBI). A key achievement includes collaborating on a groundbreaking project to estimate the total number of tree species worldwide, which identified approximately 73,300 species, highlighting the critical role of global tree diversity in ecosystem health and stability. This research underscored the threats to rare species from changes in land use and climate. FACAI's integration of global data sets and advanced computing significantly advances our understanding of global forest biodiversity.

## West Lafayette Trio (WLT)

WLT consists of Alpen Liang, Finnan White, and Marco Tindel. Alpen Liang has played piano for a decade, the majority of which came under the guidance of Dr. Ellen Bulow. He has participated in competitions such as the Hoosier State Auditions and the Sonata/Sonatina Festival, and volunteers at the Westminster Center and Universal Unitarian Church. Finnan White has played oboe for five years. He currently plays for the Wabash Youth Symphony, Indiana State Orchestra, and the Wind Ensemble at WLHS. Marco Tindel has played cello for many years. He currently plays for the Wabash Youth Symphony, Indiana State Orchestra, and the Orchestra at WLHS.