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CONTENTS



**Abstract.** Background: Roadside trees play an important role in urban landscaping. They are not only related to urban scenes, traffic safety, quality of life, and health, but also closely related to ecology and cultural development. Thus, effective, intelligent management of an area of urban roadside trees will become an important topic. Methods: This paper evaluates survey technologies and management techniques utilized in many cities of Taiwan, including surveys of roadside trees, risk assessment, and precious protected trees. A roadside tree management database was built using a geographic information system (GIS). Results: The number of urban forest trees exceeded 100,000 in our surveys, and many types of intelligent survey instruments were used to survey the trees, including real-time kinematic (RTK) and non-destructive detection instruments, radio frequency identification (RFID), in-vehicle light detection and ranging (LiDAR), and panoramic streetscape systems. A tree management system can be constructed by introducing the digitized information, which is based on a basic survey of trees. The survey stage primarily relies on manual surveys, in-vehicle LiDAR, and RFID, and then a visualized database retrieval system will be proposed using GIS. This system can be utilized for the health and foundation management of trees and the whole spatial planning of urban forests, among others. Conclusion: This research attempts to summarize the trends in intelligent management of urban forests using our practical experiences with the goal that it will be a reference for the future intelligent construction of urban forests.

**Keywords.** Geographic Information System (GIS); In-Vehicle Light Detection and Ranging (LiDAR); Non-Destructive Detection Instruments; Urban Forest; Urban Scenes.



**Abstract.** In parallel with ongoing discussions on what the concept of a smart city actually entails, use of smart technology in management and governance of urban green space is increasing. Application of smart technologies usually involves multiple sensors, smartphones, internet connections, etc., working together to make green space management more inclusive and effective. In the Sustainable Smart Parks project in Gothenburg, Sweden, new technologies are being applied and tested for availability, reliance, and relevance for contemporary management. However, moving these technologies beyond ad-hoc applications and creating a joint systems approach to future management is still unexplored. In this article, we introduce an analytical framework based on urban ecology and nature-based thinking and use it to examine the Sustainable Smart Parks initiative. The framework works well in distinguishing integration of diversity, connectivity, adaptation, inclusion, and perception in different technologies. However, further studies are needed to test adequacy of the 5 initial criteria in a wider context and to increase coupling of smart technologies that share similar focus within each criterion. This would stimulate "systems mapping" and thus clearer progression toward integrated smart green space management.

**Keywords.** Governance; Green Infrastructure; ICTs; Nature-Based Thinking; Smart City; Urban Ecology; Urban Forest; Urban Green Space; Urban Trees.



**Abstract.** Background: Urban green spaces are increasingly seen as vital resources contributing to ecological and social health. The ecological concept of patch dynamics over space, scale, and time applies to patches in urban settings and is important in understanding the complexity of relationships between and within the ecological and social spheres interacting in urban settings. Methods: This case study investigates forested and natural patches on Indiana University's Bloomington (IUB) campus. Data gathered through university archives includes historical maps and campus plans for a study period beginning in 1884 with the university's relocation to its current area. Documents were reviewed for

evidence of patches being labeled or left blank. Historic aerial photos were compared with present satellite imagery using geographic information system (GIS) software. Results: Findings include patterns where patches were indicated on maps (1902 to early 1940s), followed by a period where natural/forested areas were unindicated on maps (post-World War II to 1960s), followed by patches reappearing on maps and being suggested for preservation (1960s to present). Although some natural patches were "lost" during the study period, others persisted. Patches that endured may be defined as Commons: shared resources protected by formal/informal rule processes. Conclusions: This novel framework for the IUB patch project serves as a template for use in investigating green patches in the city of Bloomington. The Bloomington project builds upon the IUB framework, expanding GIS analysis of current patches and historical imagery, and assessing current ecological patch condition. Additional considerations reflect complexity of municipal settings and include patch ownership, socio-demographics, and equitability in access.

**Keywords.** GIS; Historical Ecology; Patch Theory; Pilot Project; Urban Ecosystems.



**Abstract.** Background: Cities consume a disproportionate amount of energy for internal temperature regulation. Being able to reduce cities' cooling load on hot summer days can decrease energy consumption while improving occupants' thermal comfort. The urban canopy is an effective shading agent, adding cooling benefits to existing buildings and streets while providing other ecological and physiological values. Yet the building and street shading dynamic is a highly complex system that involves micro-level building components and macro-level variables. Introducing urban canopy to such a complex system creates another challenge, as urban canopy variables can also interact with buildings at both micro- and macro-levels. In order to accurately represent the urban canopy shading effect, it is necessary to account for the interactions among buildings, streets, and urban canopies. Methods: This study simulates the shading effect of urban canopy measured by aerial laser scanning (ALS) in the City of Vancouver, Canada, through the integration of a Radiance daylight simulation engine and geographic information system (GIS) data. All trees detected by ALS were included in the analysis. Results: The results indicate that street surfaces receive more solar irradiance reduction than building roofs and façades (i.e., exterior walls). Neighborhoods with less density and lower buildings were shaded noticeably better than areas with higher density and taller buildings. Among Vancouver's 22 neighborhoods, 2 neighborhoods, Kitsilano and the West End, demonstrated a promising sign where both building density/height and urban canopies are maintained. There was evidence of high canopy shading and high-density urban morphologies. Conclusion: Overall, this work provided an authentic canopy assessment from single building to city scale, creating opportunities to investigate intracity urban canopy variations, equality, and the balance between urban greening and urban densification.

**Keywords.** 3D Tree Canopy Mode; Aerial Laser Scanning; Canopy Shading; Radiance Model; Street Trees; Urban Forestry.



**Abstract.** Urban forests can provide essential environmental and social functions if properly planned and managed. Tree inventories and measurements are a critical part of assessing and monitoring the size, growth, and health condition of urban trees. In this context, the parameters usually collected are diameter at breast height (DBH) and total height, but additional data about crown dimensions (width, length, and crown projection) are required for a comprehensive tree assessment. These data are generally collected by urban foresters through field surveys using tree calipers or diameter tape for DBH and the electronic ipsometer/clinometer to measure tree height and crown size. Greater detail could be achieved using a digital instrument such as Field-Map, a portable computer station, to quickly realize dimensional and topographic surveys of trees and forest stands. Additionally, the incorporation of a LIDAR scanner into a smartphone such as the iPhone 12 Pro has made this device able to measure tree attributes as well as additional spatial data in the field. In this study, we tested these 3 different measurement systems in a field sampling of an urban forest and compared them in terms of measurable parameters, accuracy, cost, and time efficiency. Furthermore, we discussed the pros and cons of each measurement approach and how the resulted data can be used to evaluate ecosystem services of trees and provide guidance on tree management in order to reduce potential risks or disservices.

**Keywords.** Digital Technologies; Field-Map; LIDAR Scanner; Smartphone; Tree Measurements.



**Abstract.** Background: People caring for urban green infrastructure, not least urban trees, play an important role in maintaining the quality of the urban environment. But what happens when information processing and knowledge generation become digitalized? This study examines digital tools developed to provide knowledge support and with ambitions of inciting stewardship. It asks what understanding they draw on, what information they broker, and how they approach uptake and use of the content they provide. Methods: We analyzed 6 different e-tools

within the context of urban green infrastructure in New York City, New York, USA. We conducted semi-structured interviews with the tool creators and assessed the e-tools themselves. Results: Our findings indicate that most e-tools are designed to provide access to different types of information about urban social-ecological systems and, passively or more actively, stimulate learning. In addition to rich, complex, exploratory digital learning environments, many tools combine virtual experiences with in-person training, workshops, and coaching. Conclusion: The observed hybrid approaches harness the power of digital platforms to enable diverse usership and share large amounts of data while employing more traditional on-the-ground organizing techniques and thus offer a way forward in an age of increasing dominance of digital data. Future research on e-tool usership, hybrid learning approaches, and connections to stewardship outcomes could enrich the understanding of how e-tools operate as well as their social-ecological potential and impact.

**Keywords.** Digital Tools; E-Tools; Knowledge Exchange; Stewardship; Urban Green Infrastructure.



**Abstract.** Although the industry has raised the standards of tree risk assessment considerably in recent years, the quality of judgements is still very variable and influenced by a wide range of factors. Due to the complexity and diversity of trees and sites, collecting and verifying relevant personal experiences takes tree assessors many years. In many countries, new tree assessors learn from a small number of experienced peers. Artificial intelligence (AI) can be used to collect and condense scattered knowledge and deploy it in a support tool for basic tree assessment. In this project, the application of a commercial AI decision-making system software (Dylogos) to tree assessment is tested. The software is based on a new dynamic nonclassical logic, which combines diverse knowledge sources to an emergent system to support visual tree assessments. A set of rules describes existing knowledge about the mostly unsharp parameters affecting the likelihood of failure and damage. The software evaluates the data collected during a basic tree assessment and provides an estimate of the level of risk posed by the tree. The result and the reasons for it are presented in plain language. Users can then examine this estimate and feed their own assessment back into the system to train it further, so that this "white" AI system is self-learning based on experience acquired in practical use. The use of AI in tree risk assessment not only supports the user but can also be used to disseminate knowledge and promote the standardization of decision-making in tree assessment. Important directions for further research and knowledge gaps related to the training of AI systems in the absence of industry-wide, agreed-upon criteria for risk identified in this project are: how to collect sufficient quality-assured data sets to define the initial set of rules; and how to assess the level of expertise of users training the system further.

**Keywords.** Artificial Intelligence; Fuzzy Logic; Tree Inventory; Tree Risk Assessment.



**Abstract.** Background: As human populations urbanize, urban forests in many areas are decreasing in canopy extent due to disruptions on several fronts, including novel pests and diseases, climate change, and changing land uses. Methods: A review of the remote sensing, computing, and environmental literature was performed to provide an overview of current technology capabilities and to detail an agenda for a modern approach to urban forestry challenges. How to prepare current and future professionals to collect and analyze "Big Data," how to implement results, and what communication skills are needed in a modern world to provide resilient urban forests in the connected future were also reviewed. Results: This paper outlines an agenda for how the urban forestry professions can identify, analyze, and manage emergent disruptions to continue to provide urban forest benefits to residents in its shade. Current remote-sensing systems, the paradigm of Big Data, and collection and analysis platforms are discussed, and relevant scenarios are provided to guide insight into managing forests with a rejuvenated perspective using remote-sensing hardware and software. Conclusions: Modern cities will require modern digital urban forestry management, and current and future professionals must be able to access and utilize technology, sensors, and Big Data to effectively perform vegetation management and communication tasks. This paper details the framework for a new era of modern urban forest management in highly connected, resilient cities.

**Keywords.** Computing; Sensors; Smart Cities; Urban Forest Management.