

LANDSCAPE RESEARCH RECORD

No. 9 | March 18-21, 2020 (Canceled due to COVID-19)

Deep Time: 100 Years of CELA

Landscape Research Record

Editor-in-Chief

Galen D. Newman, *Texas A&M University*

Co-Editors

Bambi L. Yost, *Iowa State University*
Jon D. Hunt, *Kansas State University*
Benjamin George, *Utah State University*
Yi Luo, *University of Florida*
Paul Coseo, *Arizona State University*
Judith Wasserman, *West Virginia University*
Lisa Orr, *West Virginia University*
Stefania Staniscia, *West Virginia University*
Christopher D. Ellis, *University of Maryland*
Taner R. Ozdil, *University of Texas at Arlington*
Chingwen Ching, *Arizona State University*
Dongying Li, *Texas A&M University*
Deni Ruggeri, *Norwegian University of Life Sciences*
Ole Sleipness, *Utah State University*
Byoung-Suk Kweon, *University of Maryland*
Chuo Li, *Mississippi State*
Bin Jiang, *University of Hong Kong*
David La Pena, *Pennsylvania State University*
Benjamin Spencer, *University of California-Davis*
Sohyun Park, *University of Connecticut*
Mintai Kim, *Virginia Tech*
Sungkyung Lee, *University of Georgia*
Jun-Hyun Kim, *Michigan State University*
Marc Miller, *Pennsylvania State University*
Maggie Hansen, *Pennsylvania State University*
Brett Milligan, *University of California-Davis*
Kristi Cheramie, *Ohio State University*
Sungmin Lee, *University of Connecticut*
Shan Jiang, *West Virginia University*
Wu Hong, *Pennsylvania State University*
Brian Orland, *University of Georgia*
Caroline Weswort, *Iowa State University*
David Myers, *University of Maryland*

Editorial Assistant

Zhiha Tao, *Texas A&M University*

CELA Board

Ashley Steffens, *President*
Charlene LeBleu, *Past President*
Sadik Artunc, *First Vice President*
Galen Newman, *Vice President for Research & Creative Scholarship*
Hala Nassar, *Second Vice President*
Jun-Hyun Kim, *Secretary & Vice-President for Communications
Outreach & Publications*
Ebru Ozer, *Treasurer*
Jolie B. Kaytes, *Region 1 Director*
Kirk Dimond, *Region 2 Director*
Taner R. Ozdil, *Region 3 Director*
Matthew J. Kirkwood, *Region 4 Director*
David Barbarash, *Region 5 Director*
Elizabeth Brabec, *Region 7 Director*
Nadia Amoroso, *Region 9 Director*
David N. Myers, *Region 10 Director*
Forster Ndubisi, *AoF Chair*
Yiwei Huang, *CELA Student Director*
Amanda Passero, *CELA Student Director*

CELA Executive Office

TBN Executive Director

LANDSCAPE RESEARCH RECORD is published annually and consist of papers focused on landscape architecture subject areas. Each issue is a collection of papers presented at the Council of Educators in Landscape Architecture annual conference of that year. Conference theme is expressed as the subtitle of *Landscape Research Record*. The views expressed in papers published in *Landscape Research Record* are those of the authors and do not necessarily reflect the views of the conference planning committee, or the Council of Educators in Landscape Architecture.

PEER REVIEW OF PAPERS: All papers published in *Landscape Research Record* have been reviewed and accepted for publication through the Council of Educators in Landscape Architecture's peer review process established according to procedures approved by the Board of the Council of Educators in Landscape Architecture. Reviewers are recruited by track chairs from among conference attendees and other outside experts. The track chairs also serve as co-editors in the peer review process. The Council of Educators in Landscape Architecture requires a minimum of two reviews; a decision is based on reviewer comments and resultant author revision. For details about the peer review process and reviewers' names, see **REVIEWERS** in Table of Contents.

IN THIS ISSUE: In 2020, the conference committee accepted 421 abstracts for presentation and rejected 36 abstracts. Authors of accepted abstracts were invited to submit a full paper. Because the conference was cancelled, only authors whose abstracts remained registered were eligible to submit a full paper to be sent out for review. As a result, and after initial screening, a total of 57 papers were received but only 32 papers were selected and sent out for peer review. Finally, 18 papers were accepted for publications in this issue, with 6 CELA tracks having no accepted papers. The organization of this issue follows the standard conference tracks listed in the table of contents.

All Rights Reserved.
ISSN 2471-8335



TABLE OF CONTENTS

FOREWORD	vi
REVIEWERS	vii
OUTSTANDING PAPER	
FINDING COMMON GROUND FOR AN INTERDISCIPLINARY APPROACH TO GREEN INFRASTRUCTURE Jane Futrell Winslow	206
DESIGN EDUCATION AND PEDAGOGY	1
PRODUCTIVE LANDSCAPES PAST & FUTURE: RENEWABLE ENERGY TECHNOLOGIES IN DESIGN PEDAGOGY Carolina Aragon, Margaret B Vickery	2
THE “HERE AND NOW TIME”: TEMPORARY GARDENS AS DESIGN ENQUIRY Raffaella Sini	14
HISTORY, THEORY AND CULTURE.....	33
AFFORDANCE VALUE OF 2D PLAY ELEMENTS: ADDING PERSPECTIVES FROM LANDSCAPE ARCHITECTURE Kris Fox, Emma Brodie	34
CINEMATOGRAPHY IN THE LANDSCAPE: TRANSITIONAL ZONES IN THEMED ENVIRONMENTS Benjamin George, Dave Gottwald	49
CHALLENGING FORMS OF HISTORY: THE DIALOGIC COUNTERMONUMENT Fionn Byrne	65
FOR WHITES ONLY: A TIMELY COMMENTARY ABOUT LATINOS AND LANDSCAPE ARCHITECTURE Fernando Magallanes	78
PEOPLE-ENVIRONMENT RELATIONSHIPS	86
DRIED UP: THE CHALLENGES OF DEVELOPING A NEW PLANTING AESTHETIC FOR THE INCREASINGLY ARID WEST Lori Catalano	87
SERVICE LEARNING	93
DESIGNING A LEGACY: CONTRIBUTIONS OF UNIVERSITY DESIGN ENGAGEMENT TOWARD ZION’S ICONIC WESTERN IMAGE Ole Sleipness, Carlos Licon, Jake Powell, David Anderson, David Evans, Todd Johnson.	94

SUSTAINABILITY.....	110
THERMAL DELIGHT: IMPACT OF LANDSCAPE DESIGN ON BUILDING ENERGY PERFORMANCE USING COMPUTER SIMULATION TOOLS Hossein Entezari, Victoria Goetz, Ulrike Passe, Mira Engler	111
URBAN DESIGN.....	121
ASSESSMENT OF PUBLIC SPACE VISITOR ATTITUDES ON THE PRESENCE OF UNMANNED AERIAL VEHICLES (UAVS) IN OUTDOOR PUBLIC SPACE AND THE DEVELOPMENT OF COUNTERMEASURES TO CONTROL AERIAL VISUAL ACCESS Hala Nassar, Robert Hewitt, Mary Cummings	122
GROWTH AND SHRINKAGE PRE AND POST TSUNAMI IN FUKUSHIMA PREFECTURE, JAPAN Rui Zhu, Zhihan Tao, Galen Newman, Maria Counts, Michelle Meyer, Emily Offer, Youjung Kim, Abel Táiti Konno Pinheiro, Yegane Ghezellou, Akihiko Hokugo, Tamiyo Kondo, Naoko Kuriyama, Elizabeth Maly	132
RESEARCH BY DESIGN	148
CURBING SEDIMENT: CLEANING STORMWATER TO PROTECT ECOSYSTEMS AND INVESTMENTS IN GREEN INFRASTRUCTURE Halina Steiner	149
UNKNOWN FUTURES LAS VEGAS: LANDSCAPE STRATEGY, DESIGN TYPOLOGIES, and DESIGN SPECULATION Jessica Rossi-Mastracci.....	165
GEO-SPATIAL AND DIGITAL ANALYTICS.....	176
A WEB APP FOR URBAN POLLINATOR SITE ASSESSMENT Travis Flohr, Hong Wu, Nastaran Tebyanian	177
ARTIFICIAL INTELLIGENCE SYSTEMS FOR AUTOMATED SITE ANALYTICS AND DESIGN PERFORMANCE EVALUATION David Barbarash, Yung-Hsiang Lu, Mohamad Alani, Noureldin Hendy, Peter Huang, Dhruv Swarup, Chau Minh Nguyen, Moiz Rasheed, Amogh Shanbhag, Ethan Glaser, Wenxi Zhang, Taher Dohadwala, Rohan Prabhu....	192
LANDSCAPE ARCHITECTURE FOR HEALTH	204
FINDING COMMON GROUND FOR AN INTERDISCIPLINARY APPROACH TO GREEN INFRASTRUCTURE Jane Futrell Winslow	205
DEEP TIME	217
THE IDEOLOGY OF CRITICAL REGIONALISM AS A TEACHING AND DESIGN RESOURCE FOR THE NEXT 100 YEARS OF CELA David D Hopman	218
EARLY HISTORY OF LANDSCAPE ARCHITECTURAL EDUCATION IN THE AMERICAN SOUTH Nicholas Serrano	233
APPENDIX.....	242
LANDSCAPE RESEARCH RECORD PEER REVIEW PROCESS.....	243

FOREWARD

Welcome to the ninth issue of Landscape Research Record, published by the Council of Educators in Landscape Architecture (CELA). In 2013, the CELA Board approved and adopted a procedure to become fully responsible for publishing peer-reviewed conference papers annually and named the publication Landscape Research Record (LRR). LRR is a post-conference publication and published online only.

This ninth issue of LRR is a collection of peer-reviewed papers originally scheduled to be presented at CELA 2020 in Louisville, Kentucky. The 2020 annual conference focused on research, scholarship and creative activity that highlighted the theme of “Deep Time: 100 Years of CELA” which entered into discussions and debates intended to celebrate the centennial anniversary of the existence of CELA and examine avenues of progress moving forward.

This issue contains 18 high-quality peer-reviewed papers resulting from the conference. We hope you find them to be a collection of provocative and insightful research that enriches CELA’s dialogue of research and creative inquiry on the processes of debate and discussion.

Galen Newman, PhD, ASLA, APA
Texas A&M University
Editor-in-Chief, Landscape Research Record No. 9
CELA Vice President for Research & Creative Scholarship 2018-2020

REVIEWERS

Aylin Alisan	Richard Alomar	Carolina Aragon
Joe Blalock	Jon Calabria	Jessica Canfield
Lori Catalano	Kanglin Chen	Danika Cooper
Kirk Dimond	Gareth Doherty	Chris Ellis
Mira Engler	Dominic Fischer	Benjamin George
Cynthia Girling	Celina Balderas Guzman	Howard Hahn
Soyoung Han	Catherine Harris	Nate Heavers
Martin Holland	Rob Holmes	David Hopman
Jeff Hou	Keneth Hurst	Kathleen Kambic
Jun-hyun Kim	Matthew J Kirkwood	Ann Komara
Sara Lamb	Charlene LeBleu	Sungmin Lee
Sungkyung Lee	Jingyi Li	Yi Luo
Ken McCown	Emily McCoy	Katherine Melcher
Jeremy Merrill	Holly Nelson	Galen Newman
Linda Nubani	Taner Ozdil	Keunhyun Park
Sohyun Park	Justin S. Parscher	Joseph J. Ragsdale
Hope Hui Rising	Jessica Rossi-Mastracci	Elizabeth Scott
Michael Seymour	Benjamin Shirtcliff	Mica Stantek
Peter Summerlin	Anna Maria Visilia	Phil Waite
Heather Whitlow	Jane Futrell Winslow	Hong Wu
Natalie Yates	Phillip Zawarus	Zihao Zhang

ASSESSMENT OF PUBLIC SPACE VISITOR ATTITUDES ON THE PRESENCE OF UNMANNED AERIAL VEHICLES (UAVS) IN OUTDOOR PUBLIC SPACE AND THE DEVELOPMENT OF COUNTERMEASURES TO CONTROL AERIAL VISUAL ACCESS

NASSAR, HALA

Clemson University email Hassar@clemson.edu

HEWITT, ROBERT

Clemson University email hewitt@clemson.edu

CUMMINGS, MARY

Duke University email m.cummings@duke.edu

1 ABSTRACT

Use of unmanned aerial vehicle (UAV) technology is predicted to increase dramatically from more than 600,000 drones registered just with the US Federal Aviation Administration (FAA) to nearly 7,000,000 over the next 12 years (FAA 1,2) This popularity is evident in their increasing use in and around public outdoor spaces, including parks, stadiums, outdoor amphitheaters, festival grounds, or outdoor markets. While there is considerable research on unmanned aerial vehicle (UAV) applications and navigation (Koh 2012, Nemeth 2010) and an emerging body of work in landscape architecture (Kullmann 2017, Park 2016), there is no research addressing increasing conflicts between public space visitors, drone navigation in public space, and its effect on the planning and design of public space. The paper presents initial findings from funded research to develop landscape architectural design and planning responses supporting low cost detection technology to deter the illegal use of drones in public spaces. Methods of data collection employed surveys of botanical garden visitors concerning their preferences for site landscape features and experiences, their awareness, attitudes, and preferences about the presence of drones in public space, and potential aerial visual access to a range of forested and open landscapes frequented by visitors in the garden. Findings suggest that given public concern about the presence of drones, landscape planning and design of such public spaces should provide continuous landscape features with restricted aerial visual access surrounding and connecting public areas with open aerial visual access.

1.1 Keywords:

Drones, Countermeasures, Urban Design, Public Space

2 BACKGROUND

Use of unmanned aerial vehicle (UAV) technology is predicted to increase dramatically in the United States alone from more than 600,000 drones registered with the US Federal Aviation Administration (FAA) to nearly 7,000,000 over the next 10 years (FAA1,2). This projected dramatic increase is accompanied by their increasing presence in and around public outdoor spaces, including a wide variety of park settings, stadiums, outdoor amphitheaters, festival grounds, and outdoor markets. While there is clearly an extraordinary amount of anecdotal evidence, as well as considerable research on unmanned aerial vehicle (UAV) applications and navigation (Koh 2012, Nemeth 2010) and an emerging body of work in landscape architecture (Kullmann 2017, Park 2016), there is no research addressing perceived conflicts between UAVs and public space visitors and drone navigation in public space.

UAV presence in public space venues stems from heretofore unattainable vantage points and visual accessibility open to UAV users. To that point, most common drone applications utilize cameras for aerial photography capturing unique viewpoints that are often superior to flights using manned helicopters, at a fraction of the expense. With increasing hobbyist drone popularity, parks, gardens, and other open public areas have come to serve as important practice locations for drone navigation and videography experimentation. Accordingly, as drone use has increased, both amateur and commercial drone pilots have increasingly sought to capture the excitement of live music events (Carter 2013), to film exclusive angles of athletic matches (Petel 2016, Hammel 2017, Sportscaster 2017, Pekler 2016), or to create powerful imagery from landmarks and monuments (Thompson 2017, Kushir 2017).

The use of unmanned aerial vehicles (UAVs) with these purposes in mind has opened significant commercial opportunities (Cohn 2017). Public space managers holding popular events such as sports matches, music concerts, theater productions, or festivals actively seek aerial perspectives of their events for advertising or broadcasting. Because such events are often intermittent and can require a wide variety of spatial and technological configurations to meet those available through the use of UAVs, it is simply not physically or financially feasible to install permanent camera systems such as “Skycams” (Cone 1985) and other permanent systems commonly used in sports stadiums under these circumstances. With recent changes in FAA rules sanctioning commercial drone operations, drone aerial photography and videography services for these and other intermittent events have increased dramatically.

Proposed commercial UAV functions include the delivery of small to large payloads quickly across long distances, such as those proposed by Amazon’s PrimeAir service (Amazon 2017); those proposed for aerial shuttle service in to major airports like JFK; and those by proposed by citywide drone taxi services. Utilities and communication carriers are employing UAVs to improve public safety and improve efficiency in cases such as AT&T’s proposal to boost cell phone service at outdoor concerts and sporting events as a means for improving connectivity and patron experience (French 2017, Kastrenakes 2017), and PG&E is proposing UAVs to examine power line wear and potential failure of improving customer service and reducing chance of fire in wildlands. Whatever the rationale for their use, drones have great potential as collaborative robots working with humans in public spaces. Given this rapid increase in UAV applications and their increasing presence in outdoor public space it behooves landscape architects to consider not only how drones might be used beneficially in public environments, but also how they might negatively impact visitor presence and experience.

The unauthorized or illegal flight of drones in outdoor public space, however, pose risks for both venue management and users, potentially threatening the safe operations of legitimate drones supporting such events. Novice unauthorized drone pilots navigating these settings increase the risk of colliding with other UAVs or otherwise losing control and damaging people or property. Such incidents have occurred at music events (injuring singer Enrique Iglesias) (Reed 2017, Kuo 2017), at sporting events (Talinova 2017), at street markets (S B 2016), and the White House. There is evidence of UAVs use to intentionally harm or distress venue attendees and VIPs, and to carry weapons (kinetic, biological, or chemical) as part of an attack. Terrorist groups such as the Islamic State of Iraq and Syria (ISIS) and Hezbollah have used drones to carry explosives for such ends in the Middle East (Schmidt 2017). Drones have also been

used to make political statements, landing on the house of the Japanese Prime Minister carrying radioactive material (BBC 2017), and landing on a stage near German Prime Minister Angela Merkel at a speaking event (Bittel 2017). Some fear that just as UAVs might support improved cell phone connectivity, so might they also be used as a platform for hacking electronic devices to disrupt security and first responders.

Two principal approaches defining contemporary response to unauthorized drone use in and around public space, include: 1) Detection of potential threats within airspace of interest (“detection”), and 2) Appropriate countermeasures deployed to mitigate drone threats (“countermeasures”). Both approaches are inextricably related to drone function, capabilities, and flight location characteristics. Appropriate countermeasures employ three primary responses: 1) Regulations and standards, 2) Active controls, and 3) Passive mitigation [35]. Regulations and standards best address the administrative, design development and organizational capacities of national and local governments, industry and manufacturers, and professional organizations to oversee and control the manufacturing, operation and use of drones. Examples include the FAA mandate for registration of drones, requirements for unique UAV license and vehicle numbers, and integrated software development enforcing drone flight practices, such as geo-fencing. Geo-fences define enforceable geographic boundaries based on global positioning system (GPS) or radio-frequency identification (RFID) preventing drone flight. While regulations and standards present useful long-term strategies for accidental drone incursions, they have, however, been ineffective in counteracting custom drone builders with malicious intent.

Active countermeasures as a response to unauthorized UAV presence are intended to interfere with drone function physically preventing continuing flight [35]. Active countermeasures fall within three categories: 1) Electronic (including jamming, hacking, and spoofing); 2) kinetic (such as guns or mobile nets); and 3) Energy (such as lasers and electromagnetic pulse devices (EMP)). Electronic countermeasures are often used to interfere with UAV sensors or their communication capacities to direct unauthorized vehicles to ground or away from defined areas. Jamming and spoofing countermeasures prompt UAV default emergency modes or deceptive flight orientation. Hacking countermeasures manipulate UAV control inputs through vulnerable security programs. Similar to the application of regulations and standards to mitigate unauthorized UAV activity, there is evidence that skilled flight configurations can mitigate electronic countermeasures (e.g., a drone goes into radio silence on final approach to a target).

Kinetic and energy countermeasures such as net guns and lasers are increasingly utilized to physically disrupt or destroy parts of UAVs, causing them to crash. Because commercial drones are relatively fragile, and because both kinetic and energy countermeasures are effective in destroying most small UAVs, accurate tracking is mandatory to avert secondary threats to people and property from destroyed drones. In fact, all active countermeasures risk uncontrolled descents, and their unintended consequences, not to mention the often significant expenses associated with sophisticated system acquisition, and operator expertise.

Passive countermeasures, in contrast, do not target UAVs, but diffuse their threat through other means. Examples include directing people at risk to safety, or blocking drone visual access through fog, directed lights or camouflage. Advantages of passive mitigation accrue from their inexpensive tracking technology, lower risks from crashes, and flexible application across a variety of sites and uses. Passive countermeasures (particularly permanent ones), however, potentially impact visitor experience in outdoor public space, and if poorly executed can adversely affect cooperative positive UAV presence.

3 LITERATURE REVIEW

The subject matter at the heart of the paper draws on literature from design-based research (DBR) addressing landscape analysis and planning applicable to: a) the creation of “drone” tracking and monitoring systems; and b) the development of model countermeasures for their use in landscape settings (Hewitt&Nassar 2019). As a process, the paper’s methodological approach draws from literature describing DBR processes in terms of: 1) conceptual development of the design problems; 2) establishment of theoretical rationale for design problem

resolution; 3) development of relevant design principles applicable to existing landscape analysis and planning practices; and 4) iteration intended to resolve complexity in human/machine/environmental design problems (Reeves, T.C. 2006). Landscape assessment methodology was derived from the literature describing SOPARC: System for Observing Play and Recreation (Park, 2016) Survey questions were informed by literature describing public attitudes and perceptions related to drones and drone activities (Sakiyama, M., Miethe, T. D., Lieberman, J. D., & Heen, M. S. ,2014). Conceptual analysis and planning of the garden's landscape features relied on literature associated with "Prospect Refuge Theory" in recreation areas (Ruddel, 1987).

4 METHODS

Research findings are in part derived from: a) garden visitor survey analysis; and 2) visual analysis of the garden's landscape. Surveys of 144 self-selected visitors at the garden's primary entrance were administered over two consecutive well-attended fall days in early November. Garden visitors were observed in its main gathering areas and principal paths those same consecutive days, congregating along forested walking paths connecting and surrounding garden clearings, and near the forest edges of garden clearings. Garden visitors were also observed in its principal open spaces in numbers consistent with visitor survey preferences.

Four representative squares of tree densities were selected for further analysis based on: 1) trunk and canopy outline; 2) ground design features (ex. pathways); 3) aerial photos of the forest canopy; 4) 3-D model perspectives of the canopy; 5) 3-D aerial views to the canopy; 6) 3-D view from understory to sky; and 7) a percentage of visual access generated through image pixel analysis. The sampled squares indicate what visitors might be doing based on features (ex. moving on pathways, resting), where they have the most visual privacy (ex. under a tree), preferred garden features (ex. views to nature), where drones have visual access to visitors, and where visitors can best see the drones. Mapped results (see Figure 4) indicate the extent of visual access throughout the garden.

5 RESULTS

5.1 Survey Responses

In brief, the survey respondents were comprised of first-time and frequent visitors travelling primarily less than 5 miles, but up to 50 miles to the garden. The vast majority spent less than 2 hours at the garden with most reporting stays between 30-60 minutes and more respondents preferring weekends, although the garden was visited throughout the week. Most respondents came in groups of 2-5, as couples, families, or groups of friends. Approximately 15% of visitors came alone.

Perhaps most relevant to the principal research issues, survey responses related to garden user preferences show that visitors utilized all areas of the garden with most visitors preferring active recreation, passive enjoyment of nature, relaxation/mediation or socializing as their primary purposes. Visitors clearly preferred three kinds of garden spaces: open space with clear views, semi-open corridors near sheltered areas, and secluded private forest areas. In their use and enjoyment of these garden areas, visitors most appreciated the garden's trees and forest, as well as feelings of comfort and safety. Nearly half of the survey respondents expressed their appreciation for the sense of privacy afforded by the garden.

Survey responses related to visitor awareness of drones and the use of drones in public space indicated that 98% of visitors were aware of drones and have heard about drones flying in public spaces through multiple sources. 11% of visitors reported owning drones. Significantly, 65 % of garden visitors reported they would be concerned seeing a drone in public space, primarily because of their fear of a loss of personal privacy or safety, for being photographed or concern about drone pilot intent. While the majority of visitors did not contemplate changing their public space behavior in the presence of drones, 41% of garden visitors said they would reassess their activities or move away from the drone, and 47% of the garden visitors indicated that public open space should be designed to deter drone intrusion.

Visitor Preferences: Sarah Duke Botanical Garden

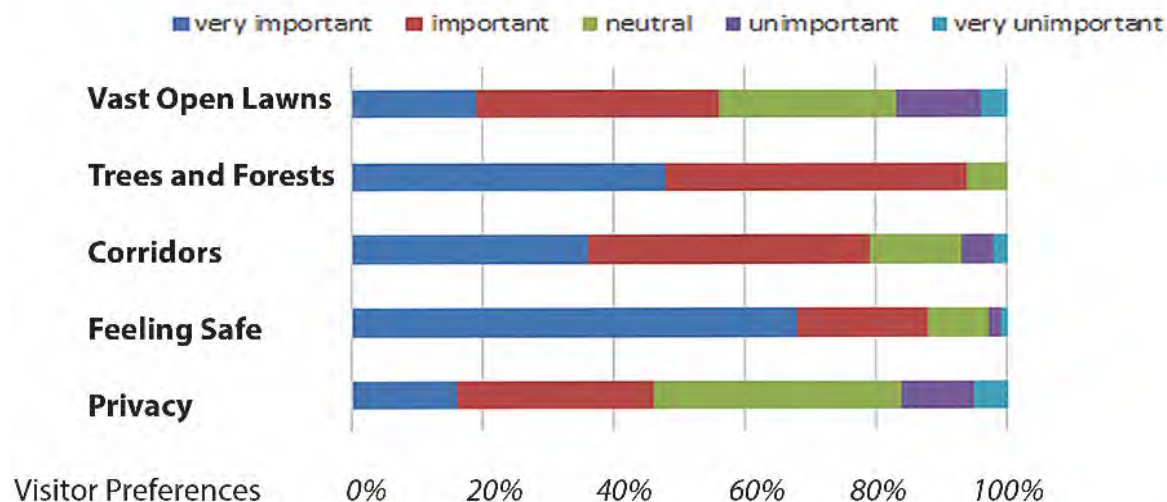


Figure 1. Select visitor landscape and personal preferences associated with visual access.

Visitor Concern About the Presence of Drones: Sarah Duke Botanical Garden

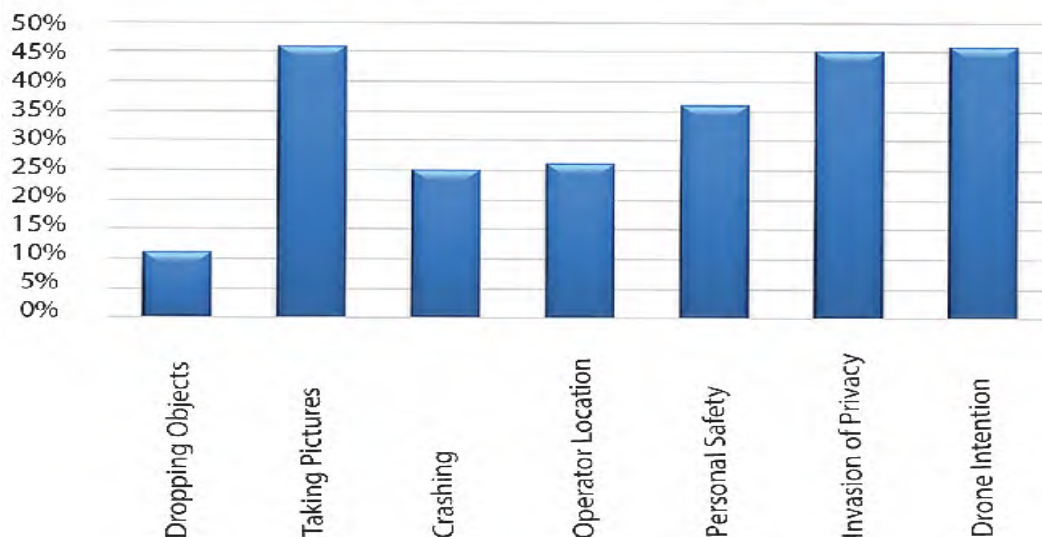


Figure 2. Select visitor concerns about the presence of drones in public space.

As a whole, these responses suggest that nearly all the garden's users across a range of ages, over a wide range of garden landscape features, preferences and activities, were familiar with UAVS, including drone capacity to photograph and otherwise observe their surroundings. As a whole, the surveyed garden visitors occupied portions of all defined areas within the garden, and when prompted identified three principal formal design characteristics defined by degrees of openness and tree cover, suggesting the relative importance of visual access and shelter as landscape experience in the garden.

In response to proposed scenarios contemplating changes in their experience, their garden preferences and behaviors in the presence of UAVs, the majority of garden visitors readily accepted UAV presence without garden behavior modification. However, nearly half of the garden visitors expressed enough concern to contemplate changing location to more forested space with less visual access in the presence of UAVs.

5.2 Visual Access Mapping

Because garden visitor opinions concerning their garden use and enjoyment in the presence of drones suggested the importance of garden features spanning a range of open to sheltered visual access, and that visitor concerns was closely linked to concerns about drone privacy violation and photography, aerial visual access throughout the garden was considered a significant characteristic for potential garden design consideration that might allay visitor concern about unauthorized presence of UAVs.

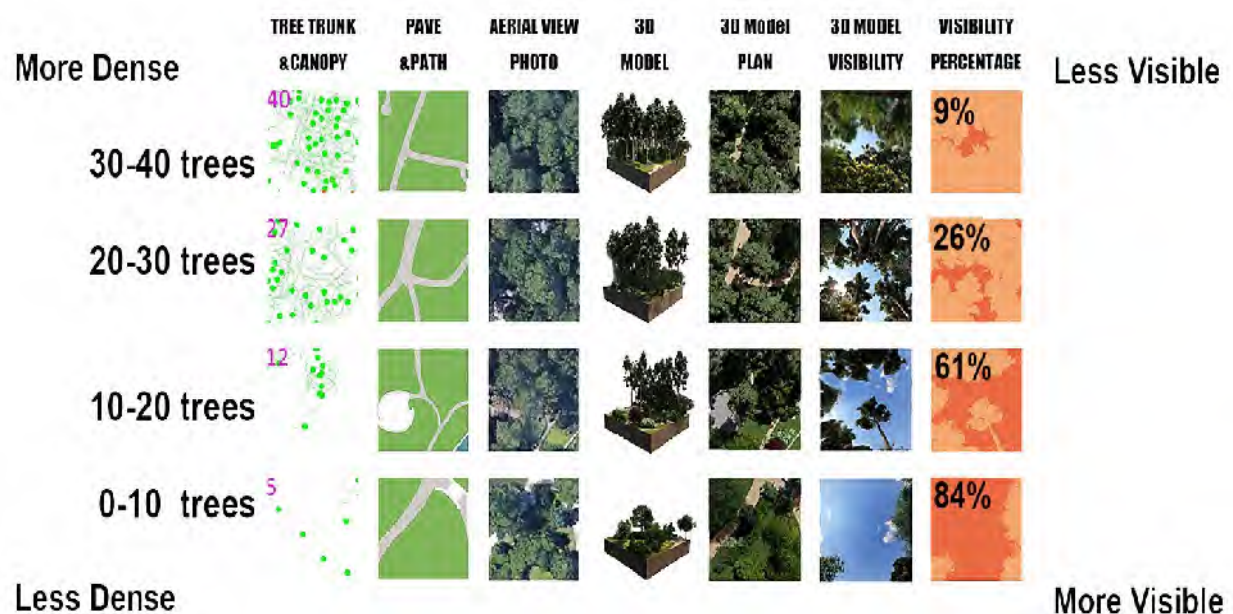


Figure 3. Visual access matrix representing tree densities in Sarah Duke Botanical Garden

Because the garden's tree cover was relatively uniform in terms of tree size, canopy coverage, and composition, the garden was consistently divided into gridded 100' squares consistent with SOPARC: System for Observing Play and Recreation and classified according to the number of trees per gridded square. The squares were subsequently categorized according to 4 tree densities, exhibiting degrees of visual access consistent with these densities. Open lawns were classified as completely visible. Mapped results indicate the extent of visual access throughout the garden.

Four representative squares of tree densities were selected for further analysis based on: 1) trunk and canopy outline; 2) ground design features (ex. pathways); 3) aerial photos of the forest canopy; 4) 3-D model perspectives of the canopy; 5) 3-D aerial views to the canopy; 6) 3-D view from understory to sky; and 7) a percentage of visual access generated through image pixel analysis. The sampled squares infer what visitors might be doing based on features (ex. moving on pathways, resting), where they have the most visual privacy (ex. under a tree), preferred garden features (ex. views to nature), where drones have visual access to visitors, and where visitors can best see the drones. (see Figure 4)

Tree Densities: Sarah Duke Botanical Garden

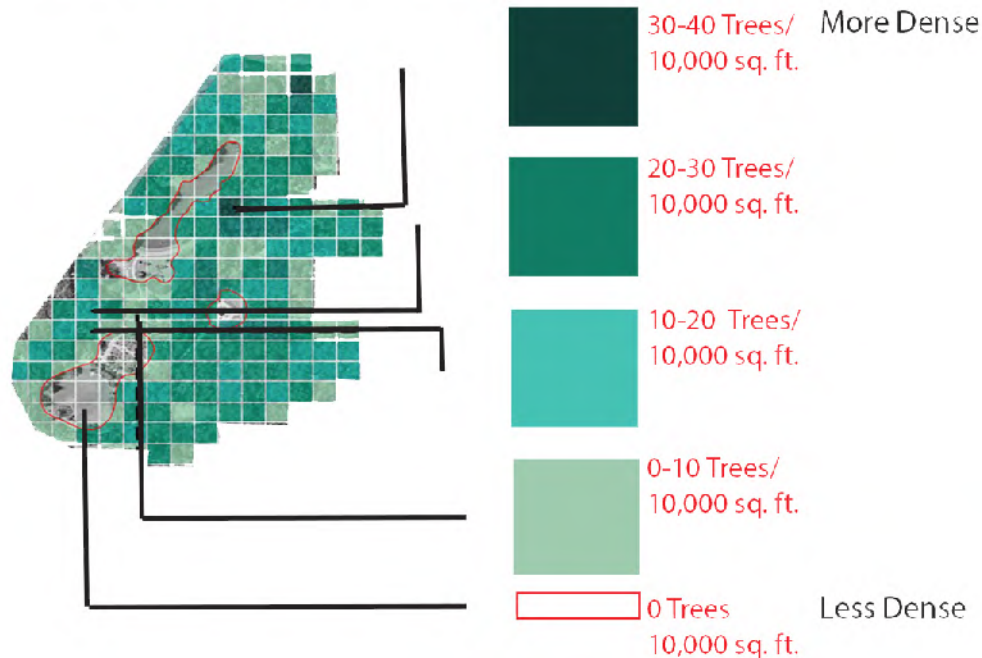


Figure 4. Visual access map representing tree densities in Sarah Duke Botanical Garden

Mapped results (see Figure 4) indicate the extent of visual access throughout the garden. The darker gridded squares representing moderate to very dense tree cover, form the exterior edge of the garden and cover most of the eastern half of the site. Two large connected open spaces run north to south along the eastern forested edge of the Garden. Tree cover and visual access are greatest in this portion of the garden. The large open space to the north is filled with a large pond surround by denser tree cover on its upper boundary, with less dense tree cover on its lower boundary connecting with the second large open space to the south. The second large open space is comprised of open lawn surrounded by less dense tree cover and is among the most used portions of the site, primarily for more active recreation and festivities. Pathways and corridors surround the large open spaces and connect dozens of botanical garden features throughout the garden.

Visitors have significant presence along the garden paths, which are largely covered with trees or border areas with tree cover. Accordingly, visual access throughout the garden features and connecting pathways is relatively good with intermittent pockets of visual access, affording the greatest shelter from UAVs. While the large open spaces offer the greatest opportunities for drone visual access, the edges bordering these open spaces allow significant additional visual access into the surrounding forest through views under the tree line, significantly reducing shelter from drones. For example, while the large open spaces in the garden occupy approximately 230,000 square feet in the garden, the modest tree cover surrounding the large open spaces and its greater visual access into the forest edges increases the drone visual access to areas in the garden to 410,000, not including the entire botanical garden boundary edges and other smaller garden areas with less dense tree cover. These additional areas add 690,000 square feet to visual access by drones. This 1,100,000 square feet of visually accessible garden represents approximately 64% of this heavily forested site, suggesting the extent of the potential influence of UAVs on the use and enjoyment of public space by a significant number of visitors to the Sarah Duke Botanical Garden.

6 CONCLUSIONS

These findings suggest that while the garden seemingly provides shelter for privacy through substantial tree cover plantings, it may otherwise be significantly compromised with the presence of commonly available drones. Accordingly, though seemingly secure, forest edge conditions can surpass open space as a means of overall visual access. These findings also suggest that while a significant number of garden visitors may contemplate adverse changes in their use and enjoyment of visually accessible portions of the garden in the presence of drones, the majority of garden visitors remain largely unaffected by the presence of drones in the garden. As a whole, these findings suggest the importance of aerial visual access as a potential significant determining factor in public space planning and design, especially as UAV presence increases into the immediate future.

7 REFERENCES

Amazon, "Amazon Prime Air," *Amazon.com*, Accessed 4 1 2017 from <https://www.amazon.com/Amazon-Prime-Air/b?ie=UTF8&node=8037720011>.

Bittel, J.. *German Pirate Party Uses Drone to Crash Angela Merkel Event*, *Slate Magazine*, Accessed 4 1 2017. http://www.slate.com/blogs/future_tense/2013/09/18/german_pirate_party_uses_drone_to_crash_event_with_chancellor_angela_merkel.html.

Carter. *Warped Tour 2013 - FIRST EVER Quadcopter Drone Concert Footage*, *Enochmagazine.com*, Accessed 5 1 2017. <http://www.enochmagazine.com/articles/videos/warped-tour-2013-first-ever-quadcopter-drone-concert-footage>.

Cohn, P., Green, A., Langstaff, M., & Roller, M. (2017). *Commercial drones are here: The future of unmanned aerial systems*. McKinsey & Company

FAA 1. *Drone Registration Marks First Anniversary*, *Federal Aviation Administration*, Accessed 27 12 2016, <https://www.faa.gov/news/updates/?newsId=87049>.

FAA 2. *Releases 2016–2036 Aerospace Forecast*, *Federal Aviation Administration*. Accessed 4 15 2018, <https://www.faa.gov/news/updates/?newsId=85227> (retrieved April 15, 2018).

French, S., *AT&T thinks drones can fix terrible reception at baseball games*, *MarketWatch*, 2016, Accessed 5 1 2017, <http://www.marketwatch.com/story/att-thinks-drones-can-fix-terrible-reception-at-baseball-games-2016-07-13>.

Hammell, B., *Drones Being Utilized at Sochi Olympics*, *QuadHangar*, *QuadHangar*, 2015, Accessed 4 1 2017, <http://www.quadhangar.com/drones-being-utilized-at-sochi-olympics/>.

Hewitt, R, Nassar, H., (2019) Design Research Based Development of Camouflage Landscape Features to Prevent Criminal UAV Activity, *Landscape Research Record Vol 7*

Kastrenakes, J., *AT&T wants drones to provide cell service at concerts*, *The Verge*, 2016, Accessed 5 1 2017, <http://www.theverge.com/2016/7/13/12171974/att-cell-drones-flying-cows>

Kullmann, Karl. (2017). The Drone's Eye: Applications and Implications for Landscape Architecture, *Landscape Research*: 1–16.

Kuo, V., *Enrique Iglesias injures hand in concert drone mishap*, *CNN*, 2015, Accessed 5 1 2017, <http://www.cnn.com/2015/05/31/entertainment/enrique-iglesias-drone-feat/>

M. Kushnir, *DJI Phantom 2 Drone Washington Monument DC*, YouTube, 2014, Accessed 5 Jan 2017, <https://www.youtube.com/watch?v=d9oHJae5qW8..>

Nemeth, Jeremy, and Justin Hollander (2010). Security zones and New York City's shrinking public space, *International Journal of Urban and Regional Research* 34.1, 20-34.

Park, Ewing (2016), The usability of unmanned aerial vehicles (UAVs) for measuring park-based physical activity, *Landuse and Urban Planning*, www.elsevier.com/locate/landurbplan,

Patel, S., *Eye in the sky: Fox Sports is bringing drones to sporting events - Digiday*, Digiday, 2017. Accessed 27 12 2016, <http://digiday.com/publishers/eye-sky-fox-sports-bringing-drones-sporting-events/>.

L. Pekler, *The Future of Drones in Live Sports Coverage and Sports Performance Analysis - sUAS News - The Business of Drones*, "sUAS News - The Business of Drones", 2016. Accessed 27 12 2016, <https://www.suasnews.com/2016/03/42568/>.

Ruddell, E. J., & Hammitt, W. E. (1987). Prospect refuge theory: A psychological orientation for edge effect in recreation environments. *Journal of Leisure Research*, 19(4), 249-260.

S. B., *Drone drops from sky at Clement Farmer's Market; pilots object to being photographed Richmond District Blog*, *Richmondsfblog.com*, 2016, Accessed 27 12 2016, <http://richmondsfblog.com/2016/01/25/drone-drops-from-sky-at-farmers-market-pilots-flee-frompaparazzi/>.

Sakiyama, M., Miethe, T. D., Lieberman, J. D., & Heen, M. S. (2014). Nevada vs. US residents' attitudes toward surveillance using aerial drones. *Submitted to the Center for Crime and Justice Policy*, University of Nevada, Las Vegas, NV.

M. Shear and M. Schmidt, *White House Drone Crash Described as a U.S. Worker's Drunken Lark* *Nytimes.com*, 2015. Accessed 27 12 2016, http://www.nytimes.com/2015/01/28/us/white-house-drone.html?_r=0

Reeves, T. C., Design research from the technology perspective (2006). In J. V. Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational design research* (pp. 86-109). London: Routledge.

Sportscaster. *Women's World Cup TV Coverage Gets High Tech Treatment - Sportscaster Magazine*, "Sportscaster Magazine", 2015. Accessed 5 1 2017, <http://www.sportscastermagazine.ca/on-air/womens-world-cup-tv-coverage-gets-high-tech-treatment/1003407659/>

Talanova, J., *Drone slams into seating area at U.S. Open*, CNN, 2015. Accessed 4 1 2017, <http://www.cnn.com/2015/09/04/us/us-open-tennis-drone-arrest/>.

Thompson, F., *WATCH: Amazing drone footage of our region – and meet the man behind it*, *Shieldsgazette.com*, 2015. Accessed 5 1 2017, <http://www.shieldsgazette.com/news/watch-amazing-drone-footage-of-our-region-and-meet-the-man-behind-it-1-7196389>

Figure 1. Select visitor landscape and personal preferences associated with visual access. Diagram by author.

Figure 2. Select visitor concerns about the presence of drones in public space. Diagram by author.

Figure 3. Visual access matrix representing tree densities in Sarah Duke Botanical Garden. Diagram by author.

Figure 4. Visual access map representing tree densities in Sarah Duke Botanical Garden. Diagram by author.

Acknowledgments

The paper presents initial findings from research funded by a multiyear NSF grant to develop landscape architecture design responses related to the use of UAVs in and around public outdoor spaces,