

# Audience Environmental Awareness at Performances of *Inuksuit*

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EES201 – Introduction to Geographic Information Systems – Fall 2013, Furman University, Greenville, SC



## Introduction

Unprecedented population growth and the constraints of finite resources constantly highlight the relationship between humans and our environment. Study of this relationship often necessitates an interdisciplinary approach, and the union of natural and social sciences is becoming prevalent in much of academia. Ecomusicology, a long-existing but recently titled concept, is emerging in both musical and scientific circles as an independent branch of musicology. Dr. Aaron Allen defines the field as a combination of musicology with "ecocriticism": the study of "cultural products...that imagine and portray human/environment relationships variously from scholarly, political, and/or activist viewpoints" (2011). Within this field, composers such as Charles Ives, Matthew Burtner, and John Luther Adams are utilizing and emulating natural elements and places in their works. This research will focus on one musical work by John Luther Adams, a modern American composer who has written what is likely the largest collection of ecocentric music to date.

As a student involved in both music and the natural sciences, I aim to examine the role ecocentric music may play in environmental education, communication, and advocacy. Specifically, I will investigate audience behavior during performances of John Luther Adams' *Inuksuit*, a concert-length work scored for nine to ninety-nine percussionists. Composed specifically for outdoor performance, Adams calls *Inuksuit* "site determined" (Herzogenrath 2012). Performers are arranged according to loose guidelines in the score, and audience members are free to move among and around the musicians throughout the performance.

## Literature Review

Hägerstrand's time-space geography, first proposed in the 1960s, integrates the study of human movement through space and time in order to "help researchers investigate individual behaviors in a spatiotemporal environment." Movements are visualized as three-dimensional space-time paths, showing spatial movements in the *x* and *y* directions and temporal movements in the upward *z* direction (Shaw et al., 2008). Kwan and Lee (2003) combine this method with geovisualization to create activity density patterns "for representing and comparing the density patterns of different activities in real geographic space." Shaw et al. (2008) also use geovisualization in combination with space-time paths to create "generalized space-time paths (GSTPs)" for use with extremely large datasets.

Tracking spatiotemporal movements of humans and other species has become increasingly relevant in monitoring pollutant exposure. Gulliver and Briggs (2004) developed a Space Time Exposure Modeling System (STEMS) in order to utilize time geography for just such a purpose. Jerrett et al. (2005) provide a comprehensive review of exposure modeling systems, discussing the uses, technological requirements, and effectiveness of six prevailing models. Several aspects of these visualizations seem to parallel the methods of the "audio cartography" of Kornfeld, Schiewe, and Dykes (2011). Their cartography consists of sound models based on source type, frequency, spatial reach, and several other factors. Papadimitriou et al. (2009) discuss another aspect of audio cartography: the visualization of a soundscape, defined as the "perceived acoustic environment in a landscape scale." They propose "considering sound as a geographic feature that might be described by specific attributes," particularly origin, type, and magnitude. This research will combine time-space geography with sound modeling in analysis of outdoor performances of *Inuksuit*. Audience movement will be tracked and modeled using GPS devices and 2D space-time paths, while sound dispersion from musical performers will be modeled using methods similar to those described above.

## Methodology

- Elevation data for the Sarasota site were obtained through the US Geological Survey's (USGS) Earth Explorer and downloaded in LIDAR (Light Detection and Ranging) form. This 2009 raw LIDAR data was used to create an LAS dataset, which was then manipulated into rasters through ESRI ArcMap 10.2 and modeled in 3D through ESRI ArcScene.
- Furman University obtained internally processed LIDAR data from the Geographical Information Systems (GIS) division of Greenville County. These 2010 data, in the form of a point cloud, were clipped to the size of the study area (Furman University's campus), and raster DEMs and TINs were created from the clip.
- Tracks were created within ArcMap to simulate the paths of audience members. These polylines were split into segments at their vertices, and each segment was given a time-stamp in the style of a GPS device. The tracks were animated in ArcMap and ArcScene to simulate the movement of the audience members through the duration of *Inuksuit*.
- Two sets of rasters and TINs were created for each site: one from ground LIDAR data, and one from first return LIDAR data. First return data has proven the better candidate for 3D visualization, while ground data has been the foundation for defining the simulated audience tracks.
- Performer positions were simulated in an ArcMap point layer, and the points were then classified in three instrument groups according to the groupings in the *Inuksuit* score. Each group was assigned an estimated decibel level according to its instruments used. Using ArcMap's Spatial Analyst tool, a kernel density raster was created to represent sound dispersion from the performers. This kernel density represents sound per unit area of the performance space, and it is intended to visualize the sounds experienced by the audience members. It should be noted that the decibel levels used are a very rough estimate and do not account for vegetation, humidity, air temperature or topography.

## References/Data Sources

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Papadimitriou, Kimon D., et al., 2009, Cartographic Representation of the Sonic Environment: The Cartographic Journal, v. 46, no. 2, p. 126-135.

Shaw, S. L., Yu, H., & Bombom, L. S., 2008, A space-time GIS approach to exploring large individual-based spatiotemporal datasets: Transactions in GIS, v. 12, no. 4, p. 425-441.

**Figure 1 Data Sources:** 1) Raster DEMs created by the author using Greenville County LIDAR data, distributed to Furman University by Geographical Information Systems (GIS) Division of Greenville County, SC (2010) 2) Tracks created by the author using Environmental Systems Research Institute (ESRI) ArcMap 10.2 Editor tools.

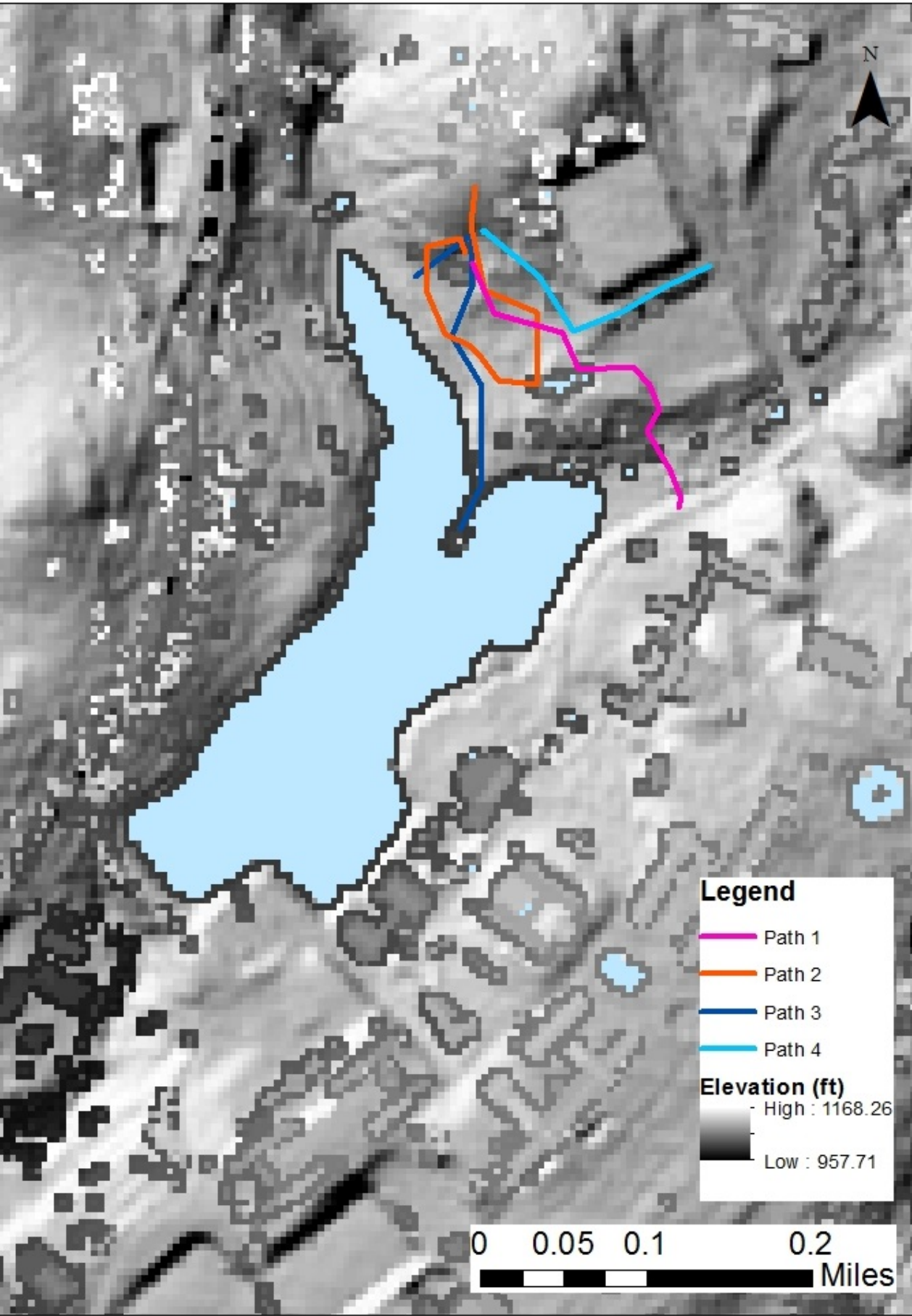
**Figure 2 Data Sources:** 1) TIN created by the author using Greenville County LIDAR data, see Figure 1 Data Sources 2) Tracks identical to Figure 1, see Figure 1 Data Sources.

**Figure 3 Data Sources:** 1) Aerial orthophoto of Greenville County, distributed to Furman University by the GIS division of Greenville County (2010) 2) Paths identical to Figure 1 and 2 3) Point layer created by the author, using ArcMap Editor tools 4) Decibel estimates based on publications from the American Academy of Audiology and from Purdue University's Department of Chemistry: <http://www.audiology.org/practice/resources/PublishingImages/NoiseChart85x11.pdf>, <http://www.chem.purdue.edu/chemsafety/training/ppetrain/dblevels.htm>

**Figure 4 Data Sources:** 1) LAS dataset created by the author based on Sarasota, FL, LIDAR data obtained from USGS Earth Explorer: <http://earthexplorer.usgs.gov/> (2007)

All maps and models created with ESRI ArcDesktop 10.2 (2013).

## Modeled Results



**Figure 1. Hillshade of Furman University campus, created from rasters of Greenville County LIDAR data. Both ground and first return rasters are displayed in order to exhibit as few "null" spaces as possible. Paths representing audience movement created using the Editor tool in ArcMap 10.2.**

## Proof of Concept

The proof of concept for this research consisted of performance site models, simulated GPS tracks and kernel density maps, and 2D path animations. All landscape models shown here are in the style of those that will be used in upcoming research. These models provide physical boundaries for audience motion, as well as a foundation for the creation of a soundscape in the style of Papadimitriou et al. (2009).

Paths shown in the proof of concept models (below) were created by the author of this study, but were animated using time-stamps similar to those stored in a Garmin eTrex GPS device. During experiments for this proof of concept, these devices were proven to store data in a manner that will be easily imported, symbolized, and animated in ArcMap and ArcScene. For the initial South Carolina models (Figures 1,2, and 3), the paths were animated in 2D using ArcMap's Animation tool. The paths appear as sequential segments according to their time-stamps and can be seen in an aerial view in both ArcMap and ArcScene.

As previously noted, the kernel density map (Figure 3) was created from rough estimates of each musician's decibel level. Based on standard decibel values, each instrument was assigned an estimated decibel value, and the average level for each instrument group was calculated. Again, these decibel levels do not account for vegetation, humidity, air temperature or topography, and were created solely for the purpose of visualizing sound dispersion over the performance area.

## Independent Study Research

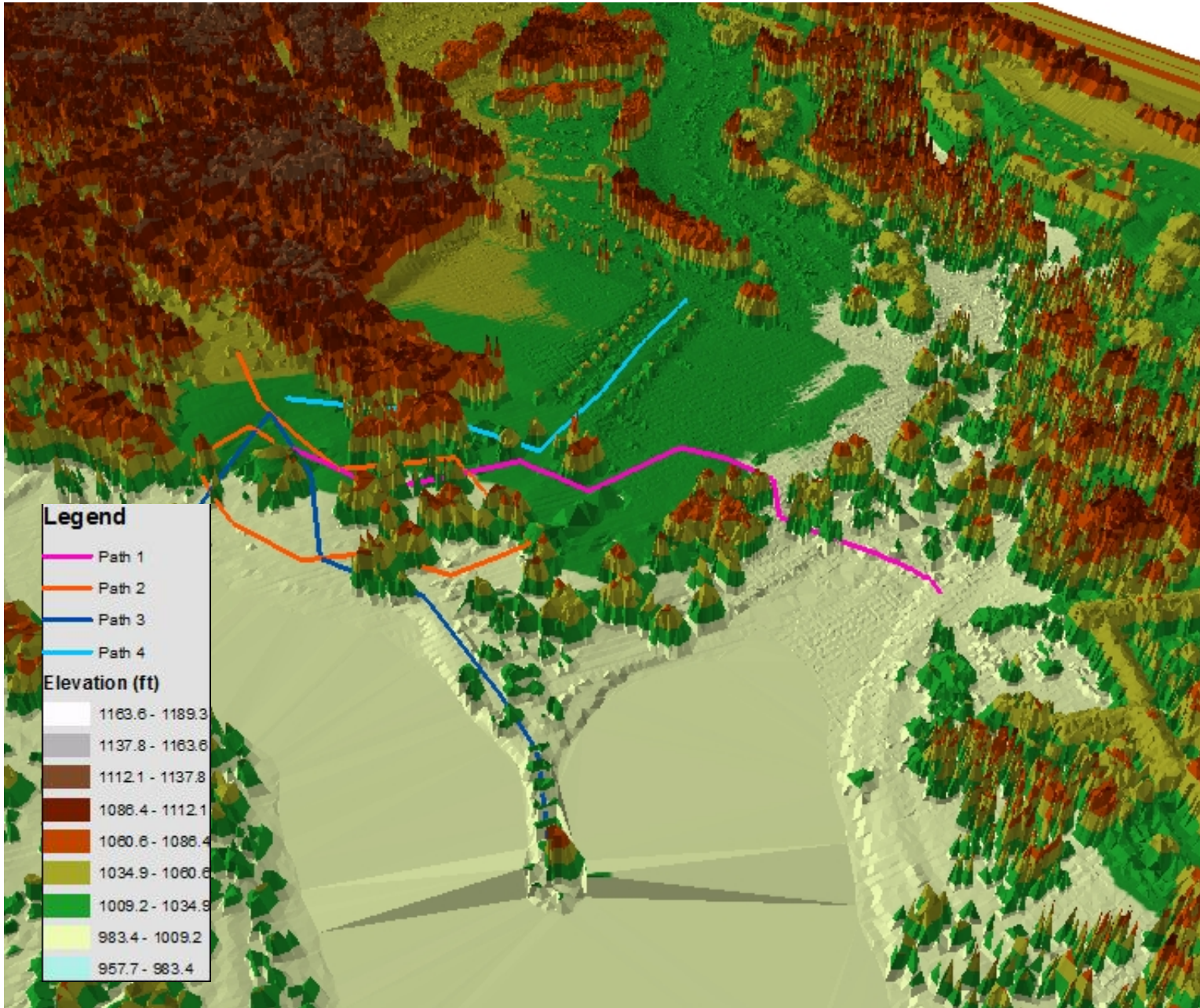
The next phase of the research will involve real-time data collection from audience members at two performances of *Inuksuit*: one in Greenville, SC, and one in Sarasota, FL. Both performances will take place in March 2014. I will examine the behavior and performance response of 10-15 audience members. Each participant will carry an eTrex device during the performance, used to monitor their path and duration of any stops. I will also collect live feedback from these audience members, via a personal voice recorder, according to pre-determined survey questions regarding their perception of sound and the surrounding environment. Audience responses will be used to evaluate *Inuksuit* as a method of raising the audience's environmental awareness and perception.

After the data collection process, audience movements will be visualized in 3D. It is my hope that these visualizations will be of a slightly larger scale than those in the proof of concept. The use of ArcScene's 3D animated model eliminates the need for a 3D space-time path in the style of Kwan and Lee (2003) and Shaw et al. (2008). Instead, the motion of each audience member will be simulated by the movement of a point through the 3D landscape model, displaying their motion in real time rather than by a vertical *z* dimension representing time passed. The participant's movement will be synchronized with a recording of *Inuksuit* by aligning the time-stamps from their GPS track with the times in the recording.

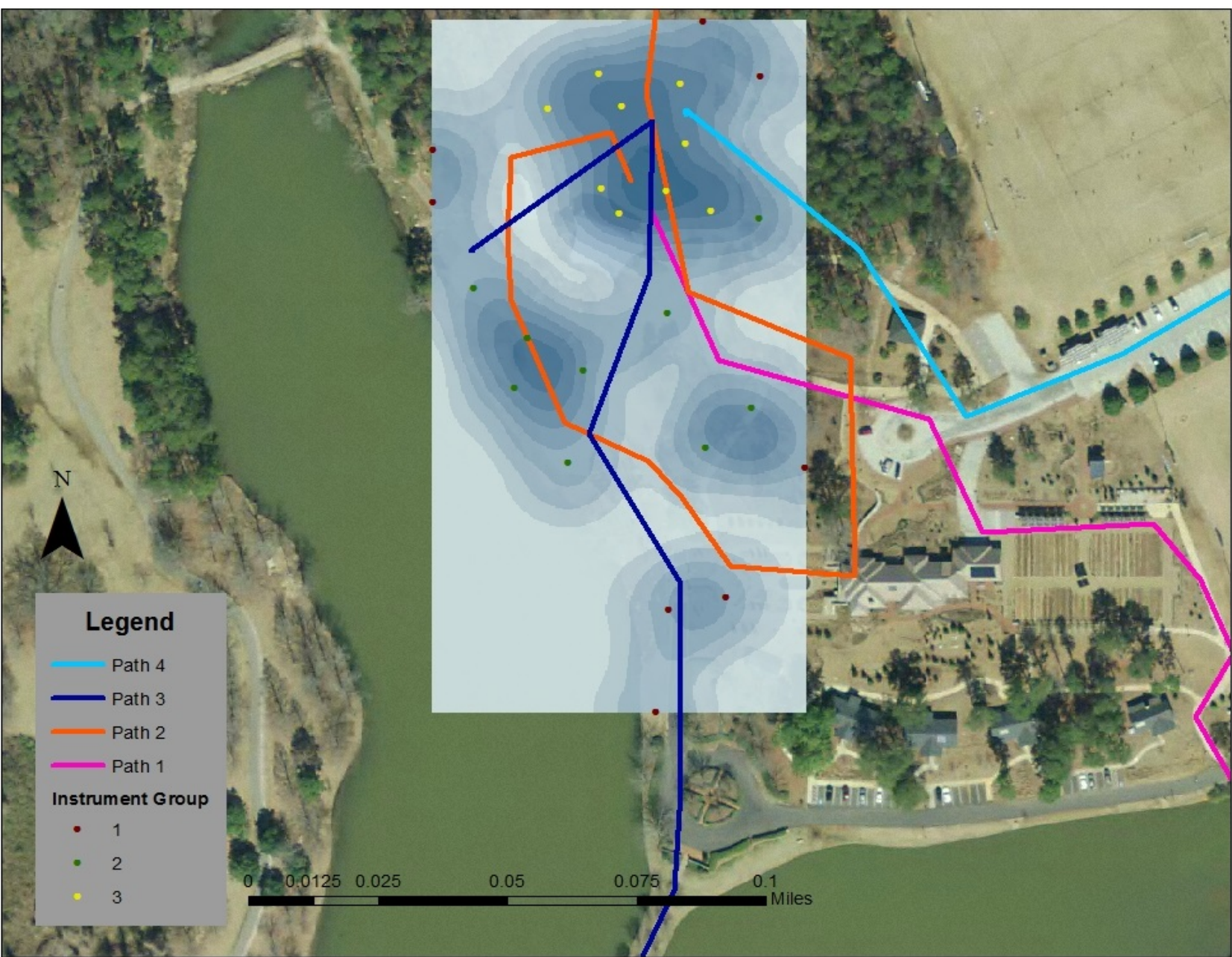
The sound modeling methods and kernel density maps will also be improved and refined. I will experiment with the modeling methods of Kornfeld et al. (2011) and Papadimitriou et al. (2009) in symbolizing the soundscape of the performance site and any patterns in sound distribution. Though much musical interpretation and timing is left up to the individual musicians, synchronicity at specific points in the piece is crucial to each performance and may result in particular patterns of audience movement. Performer positions will be marked with waypoints on an eTrex device, classified as in Figure 3, and assigned an appropriate factor to visualize their sound dispersion. A more refined estimate of decibel level is the most likely choice; however, if a more suitable attribute is discovered, it will be explored and utilized.

## Acknowledgements

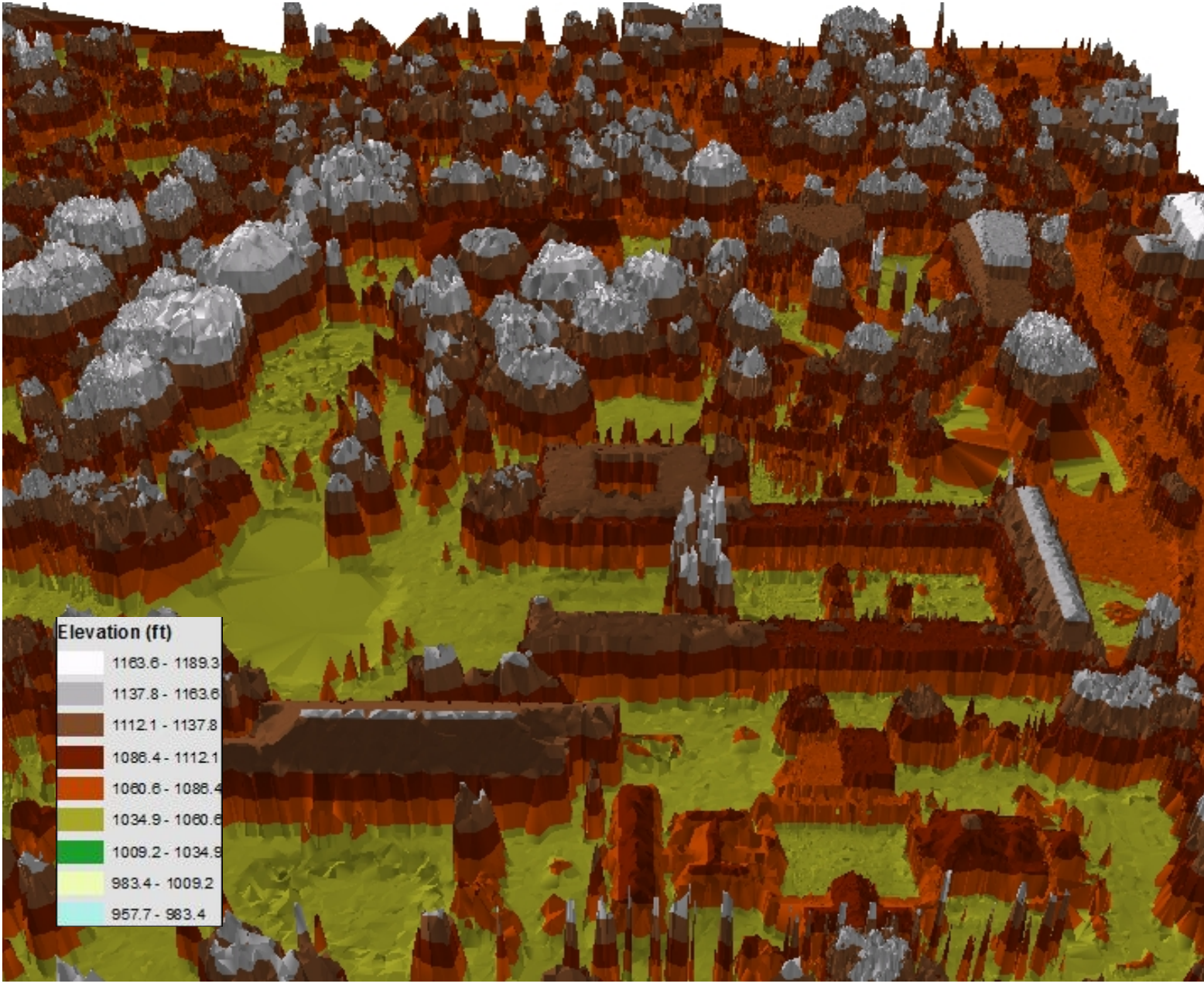
Many thanks to Mr. Mike Winiski for his wealth of knowledge and constant assistance with ArcGIS, and to Dr. Omar Carmenates for his support in solidifying this research project.



**Figure 2. TIN of Furman University campus, created from Greenville County LIDAR (first return). Vertical exaggeration factor is 2. Paths are identical to Figure 1.**



**Figure 3. Kernel density sound dispersion map. Darker areas represent a higher decibel level per unit area and therefore louder sound. Paths are identical to Figures 1 and 2, and points represent performer position within the shown area of Furman University campus.**



**Figure 4. LAS dataset of Sarasota, FL, 3D-modeled in ArcScene. Performance site will be focused around the hemi-rectangular building near the center of the frame. Vertical exaggeration factor is 2.**