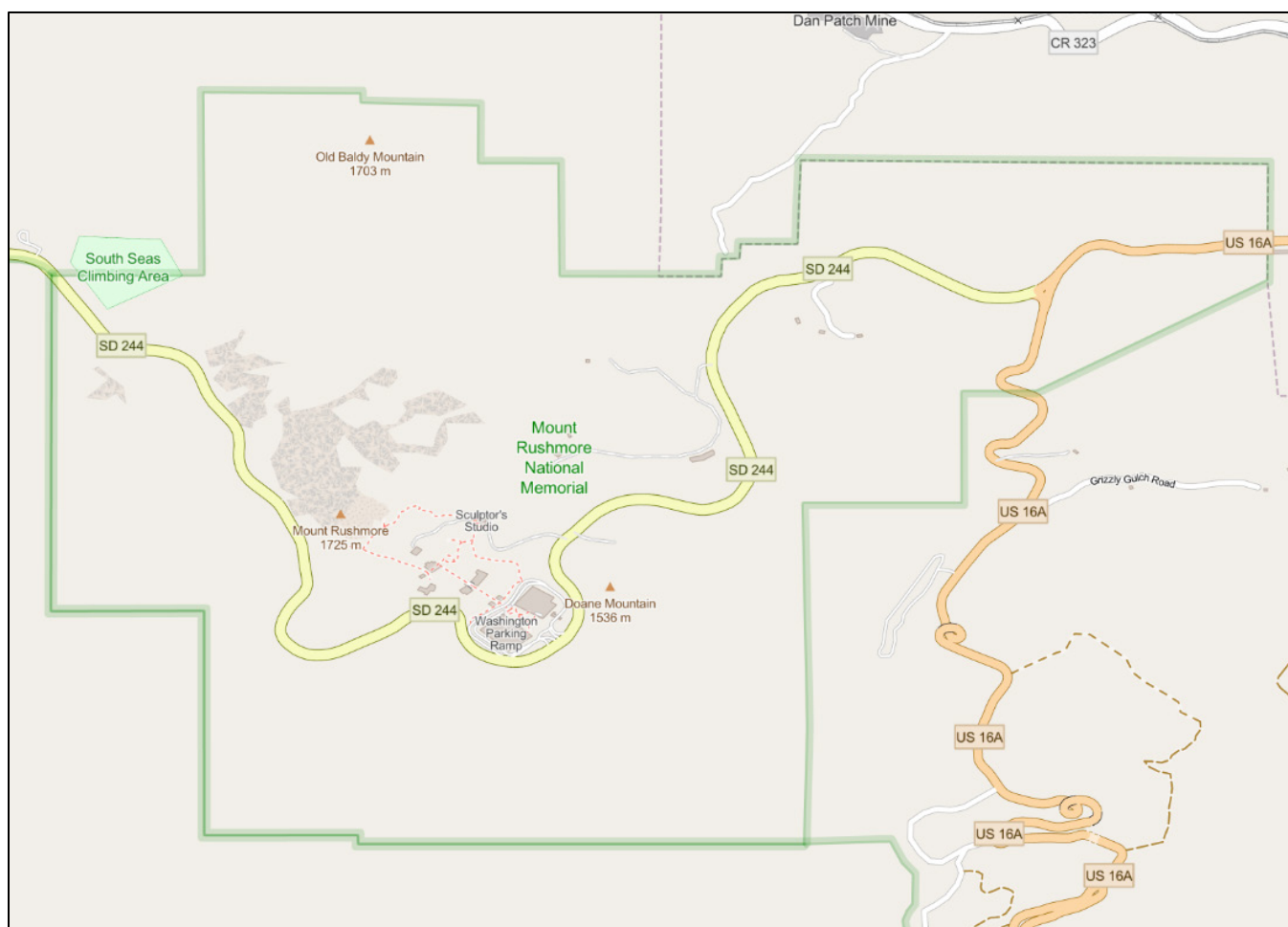




Exploring spatial patterns of overflights at Mount Rushmore National Memorial

Natural Resource Report NPS/MORU/NRR—2022/2410



ON THE COVER

Map of Mount Rushmore National Memorial produced by Brian A. Peterson (Kansas State University)

Map service layer credits: Map data © OpenStreetMap contributors, Microsoft, Esri Community Maps contributors, Map layer by Esri

Exploring spatial patterns of overflights at Mount Rushmore National Memorial

Natural Resource Report NPS/MORU/NRR—2022/2410

Brian A. Peterson¹, J. Adam Beeco², Sharolyn J. Anderson², & Damon Joyce²

¹Kansas State University
Manhattan, Kansas

²National Park Service
Natural Sounds and Night Skies Division
Fort Collins, Colorado

June 2022

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

The National Park Service, Natural Resource Stewardship and Science office in Fort Collins, Colorado, publishes a range of reports that address natural resource topics. These reports are of interest and applicability to a broad audience in the National Park Service and others in natural resource management, including scientists, conservation and environmental constituencies, and the public.

The Natural Resource Report Series is used to disseminate comprehensive information and analysis about natural resources and related topics concerning lands managed by the National Park Service. The series supports the advancement of science, informed decision-making, and the achievement of the National Park Service mission. The series also provides a forum for presenting more lengthy results that may not be accepted by publications with page limitations.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible and technically accurate.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available in digital format from the [Natural Resource Publications Management website](#). If you have difficulty accessing information in this publication, particularly if using assistive technology, please email irma@nps.gov.

Please cite this publication as:

Peterson, B. A., Beeco, J. A., Anderson, S. J., & Joyce, D. 2022. Exploring spatial patterns of overflights at Mount Rushmore National Memorial. Natural Resource Report NPS/MORU/NRR—2022/2410. National Park Service, Fort Collins, Colorado. <https://doi.org/10.36967/nrr-2293663>.

Contents

	Page
Figures.....	iv
Tables.....	v
Acknowledgements.....	vi
Abstract.....	vii
List of Acronyms	viii
Introduction.....	1
Methods.....	2
Data Collection.....	2
Phase 1 methods	2
Phase 2 methods	2
Phase 3 methods	2
Results.....	5
Results – Phase 1	5
Results – Phase 2	6
Results – Phase 3	9
Discussion.....	25
Literature Cited	26

Figures

	Page
Figure 1. Map of all overflights extending 25 miles from the Mount Rushmore perimeter (flight tracks are black color with a line width of 0.3pt and a transparency of 50%).	5
Figure 2. Map of all overflights above Mount Rushmore (flight tracks are black color with a line width of 0.3pt and a transparency of 50%).	6
Figure 3. Low-level overflights within 10-miles of Mount Rushmore.	7
Figure 4. Low-level overflight ring-pattern around Mount Rushmore.	8
Figure 5. Low-level overflights above Mount Rushmore.	9
Figure 6. Point density analysis across AGL altitude intervals.	10
Figure 7. AGL altitude trends of waypoints with 0.5 mile of Mount Rushmore boundary (n=181,711 waypoints).	11
Figure 8. MSL altitude trends of waypoints with 0.5 mile of Mount Rushmore boundary (n=181,711 waypoints).	12
Figure 9. Emerald City Aircraft Leasing Inc flight routes.	14
Figure 10. Tag Aviation Inc flight routes.	15
Figure 11. Higgins Leasing Inc flight routes.	16
Figure 12. Langbehn Land and Cattle Co Inc flight routes.	17
Figure 13. Black Hills Helicopters Inc flight routes.	18
Figure 14. Emerald City Aircraft Leasing Inc altitude distribution that ranged from 545 to 2,456ft AGL.	19
Figure 15. Tag Aviation Inc altitude distribution that ranged from 317 to 3,072ft AGL.	19
Figure 16. Higgins Leasing Inc altitude distribution that ranged from 0 to 1,853ft AGL.	20
Figure 17. Langbehn Land and Cattle Co Inc altitude distribution that ranged from 3 to 1,039ft AGL.	20
Figure 18. Black Hills Helicopters Inc altitude distribution that ranged from 975 to 2,265ft AGL.	21
Figure 19. Average number of flights per day of the week.	23

Tables

	Page
Table 1. Spatial correlation matrix of Above Ground Level (AGL) altitude point densities.....	11
Table 2. Number and percentage of waypoints across AGL altitude intervals ($n=181,711$).....	12
Table 3. Number and percentage of waypoints across MSL altitude intervals ($n=181,711$).....	13
Table 4. Number of overflights across months ($n=1,815$)*	22
Table 5. Number and percentage of overflights across hours of the day for weekdays ($n=1,146$) and weekends ($n=669$).....	23

Acknowledgements

The authors would like to thank the National Park Service Natural Sounds and Night Skies Division, and specifically Emma Brown, Vicki Ward, and Davyd Betchkal, for support, project planning, and data collection. Additionally, the authors would like to thank Michelle Wheatley, Brad Eggers, and Rene Ohms for providing support and information at Mount Rushmore National Memorial.

Abstract

The purpose of this study was to explore the spatial patterns of overflights at Mount Rushmore National Memorial (Mount Rushmore). Overflights were analyzed from August 15th, 2020 to May 15th, 2021 using Automatic Dependent Surveillance-Broadcast (ADS-B) and radar data from L3Harris. The first phase of analysis focused on all overflights and found a high concentration of overflights fly above Mount Rushmore. The second phase of analysis focused on low-level overflights that fly below 9,000ft mean sea level (MSL), which showed that many low-level overflights fly in a ring-shaped pattern around Mount Rushmore. The third phase of analysis removed all overflights known to not be air tours. Point density analysis was conducted using waypoints segmented into 500ft above ground level (AGL) altitude intervals, which showed that the density of overflights varied by altitude interval and the 1,000-1,500ft AGL range had the highest density of overflights around and above Mount Rushmore. This altitude interval also had the highest number of waypoints. It was also determined that the aircraft owners who fly the most helicopter routes fly at mean and median altitudes less than 1,600ft AGL. This information can be used for planning and management purposes and this study serves as a resource for future research that intends to use more advanced analytics.

List of Acronyms

AGL: Above ground level

ADS-B: Automatic Dependent Surveillance-Broadcast

DEM: Digital Elevation Model

FAA: Federal Aviation Administration

GIS: Geographic information systems

MORU: Mount Rushmore National Memorial

MSL: Mean sea level

NPS: National Park Service

NPATMA: National Parks Air Tour Management Act

Introduction

Mount Rushmore National Memorial (Mount Rushmore) is located in southwestern South Dakota, two miles southwest of Keystone, along State Highway 244, and is comprised of 1,278 acres. Mount Rushmore preserves a diverse cultural and natural landscape, including a traditional cultural landscape of great importance to Northern Plains Tribes, is an internationally recognized symbol of freedom and democracy, and showcases a unique engineering and artistic achievement. The majority of visitation is to see Mount Rushmore's Shrine of Democracy Sculpture and associated visitor facilities. The sculpture is also popular to view for air tours.

In 2019, commercial air tour operators reported conducting a total of 4,204 air tours at Mount Rushmore (National Park Service, 2021). The National Parks Air Tour Management Act of 2000 (NPATMA) (Public law 106-81) requires the National Park Service (NPS) to manage air tours at all units that receive more than 50 air tours per year, with the exception of Grand Canyon National Park and all national parks in the State of Alaska (Beeco & Joyce, 2019). The purpose of this report is to provide examination of the spatial patterns of overflights at Mount Rushmore, which may assist in the development of an Air Tour Management Plan for air tours at Mount Rushmore.

As of January 1, 2020, the Federal Aviation Administration (FAA) requires all aircraft that enter designated airspace to be equipped with ADS-B technology (see 14 CFR § 91.225 and 14 CFR § 91.227) (FAA, 2020). Mount Rushmore is located under uncontrolled airspace, which means ADS-B is not required on aircraft that fly above Mount Rushmore. Regardless of the airspace designation, prior studies suggest a rather ubiquitous adoption of ADS-B by aircrafts in the United States.

ADS-B signals are transmitted from aircraft and provide location information and unique identifiers to improve airspace safety and air traffic efficiency (FAA, 2018). This study analyzed overflights using both ADS-B technology as well as radar to track flights that flew above Mount Rushmore. Overflight data were obtained in partnership with L3Harris. The data discussed in this report span from August 15th, 2020 to May 15th, 2021 and include 239 days of data.

The data were comprised of 1,815 flights that were likely air tours, which is below the 4,204 air tour flights that were reported at Mount Rushmore for 2019. This was expected because the data were collected for 239 days instead of a full calendar year and data were not collected during June and July when air tour visitation is known to be high. Additionally, we assume that the combination of ADS-B and radar capture all flights that occurred over the park during these 239 days.

Methods

Data Collection

ADS-B data were collected and purchased from L3Harris (<https://www.l3harris.com/>). The acquired data were formatted as polyline shapefiles for geographic information systems (GIS) analysis. Polyline shapefiles are comprised of point data (waypoints) which contain further information, such as latitude, longitude, and altitude. Waypoint information must be extracted from polyline shapefiles using GIS software. The data consisted of a continuous collection from August 15th, 2020 to May 15th, 2021. The polyline shapefiles were imported into ArcGIS Pro version 2.8.3. The shapefiles included the following flight metadata: flight start time, flight end time, flight duration, and tail number. These shapefiles were projected to WGS 1984 Universal Transverse Mercator Zone 13N, which uses a linear unit of a meter. To explore the spatial patterns of overflights at Mount Rushmore, analysis was conducted in three phases. All maps produced during analysis used Esri basemaps with service layer credits for: South Dakota Game Fish and Parks, Esri Canada, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, and USDA.

Phase 1 methods

The purpose of the first phase was to explore all overflight paths above Mount Rushmore regardless of flight type or altitude. Thus, polyline shapefiles were not cleaned of any flight types nor was an altitude threshold implemented. Two maps were produced. The first map was constructed to display all overflights extending 25 miles out from the Mount Rushmore perimeter. This distance was chosen to capture the entire Black Hills area to understand airspace use more broadly. The second map was constructed to display all overflights within a half-mile of the park perimeter. The half-mile buffer was chosen because that is the statutory (NPATMA) defined space for air tours over NPS units.

Phase 2 methods

The purpose of the second phase was to understand low-level overflights above Mount Rushmore regardless of flight type. Low-level overflights were identified as having an altitude less than 9,000ft MSL. This altitude was chosen because the highest point at Mount Rushmore is 5,725ft (Poluga & Shakoor, 2019), and approximately 3,000ft above the highest point in the park would capture the flights that had the greatest impact on the acoustic environment in the park. To understand flight altitudes, the polyline line shapefiles were converted to point shapefiles using the 'Feature Vertices to Points' tool. Point data with altitudes above 9,000ft MSL were excluded and the remaining data were clipped to a 10-mile buffer around the Mount Rushmore perimeter. The 10-mile buffer was chosen to gain an understanding of multiphasic travel patterns near Mount Rushmore. Three maps were produced. The first map was constructed to display low-level overflights extending 10 miles from the Mount Rushmore perimeter. The second map is similar to the first map but is zoomed in to explore low-level flight routes that form a ring pattern around Mount Rushmore. The third map was constructed to examine low-level overflights within a half-mile of the Mount Rushmore perimeter.

Phase 3 methods

The purpose of the third phase was to focus on air tours above Mount Rushmore by removing all overflights known to not be air tours. The original polyline shapefiles were again converted to point

shapefiles. Next, data were cleaned of civil patrol, survey flights, and flights with a straight-line path. Civil patrol flights were removed from analysis because of their infrequent nature and known purpose (i.e., not air tours). Civil patrol flights were identified by inputting tail numbers into the FAA Releasable Database (FAA, 2021) and retrieving owner names that were civil patrol flights (e.g., Civil Air Patrol). Survey flights were also removed from analysis because of their infrequent nature and known flight purpose. Survey flights were identified using visual analysis of flight spatial behavior, which was conducted for all flights. Survey flight behavior can be identified when a flight route consists of consecutive back and forth lateral movements in a parallel progression. Air tour behavior generally consists of flight routes that veer toward sightseeing locations and consist of sporadic S-turns and loops (Beeco & Joyce, 2019). Flights with straight-line paths were also excluded from analysis because these are flights that travel above Mount Rushmore in a direct path towards a destination (e.g., major airlines) and are clearly not air tours. Straight-line flight paths were identified using a sinuosity calculation and then visually inspected. Sinuosity is a measure of how much a linear feature deviates from a straight-line condition and can be calculated as the ratio of total flight path length to the straight-line distance between a flight's initial and final waypoint. A perfectly straight flight path would have a sinuosity of one, but as the number of meanders in the path increases (e.g., the characteristic back and forth of survey flight behavior) sinuosity will begin to approach zero. All overflights that received sinuosity values greater than or equal to 0.80 were visually inspected to validate straight-line flight paths were flown and these were subsequently removed from analysis. After this cleaning step, the remaining flights are very likely to be air tours, but without cross checking with every operator or plane owner, a definitive confirmation that all remaining flights are air tours is not possible.

Using the point data cleaned of all civil patrol, survey, and straight-line flights, above ground level (AGL) altitudes were determined for every waypoint. A 10x10 meter digital elevation model (DEM) (United States Geological Survey, 2021) was used to determine AGL altitudes of every waypoint. The AGL altitudes were calculated by subtracting the reported altitudes of the ADS-B logger minus the elevation of the DEM for every point location (x, y) (see Beeco et al., 2020 for exact method). Using a 500ft AGL altitude interval, point data were segmented (0-500ft AGL; 500-1,000ft AGL; 1,000-1,500ft AGL; 1,500-2,000ft AGL; 2,000-2,500ft AGL; 2,500-3,000ft AGL; 3,000-3,500ft AGL; 3,500-4,000ft AGL; >4,500ft AGL) and point density analysis was conducted for each altitude interval. Because each altitude interval had different amounts of waypoints, density classifications were normalized across altitude intervals. To do this, the altitude interval with the most waypoints (1,000-1,500ft AGL) was used to normalize density classification, which required two steps. First, the 1,000-1,500ft AGL altitude point density was classified using equal interval percentage breaks with five intervals of 20%. These percentage breaks were determined using the maximum waypoints per square kilometer as the '100%' value. Second, the maximum number of waypoints per each 20% interval were then applied to point density classifications for the other altitude intervals. These steps are necessary to ensure density is calculated the same across altitude intervals regardless of the number of waypoints. A figure was constructed that displays point density analyses across sequential altitude intervals (beginning with the lowest altitude range) until an altitude interval showed no density hot spots. After these steps were

accomplished, point density outputs were statistically compared for relatedness using the 'Band Collection Statistics' tool which conducted a correlation test.

Next, descriptive analyses were conducted to understand waypoint spatial distribution and quantity across altitude intervals. Descriptive analyses were also conducted to understand number of flights across months, day of the week, and hour of the day. Lastly, overflight maps were constructed for the five aircraft owners who conducted the most rotorcraft (helicopter) tours. Maps were constructed to display overall routes to gain an understanding of their multiphasic travel. For these operators, point data within 0.5mi of the Mount Rushmore perimeter were used to determine waypoint altitude distribution.

Results

Results – Phase 1

The research team mapped overflights for all flights ($n=2,219$). Figure 1 shows all overflights extending 25-miles from the Mount Rushmore perimeter and shows a high concentration of flights above Mount Rushmore. Figure 2 shows all overflights above Mount Rushmore and shows a flight corridor along the southeast corner of Mount Rushmore.

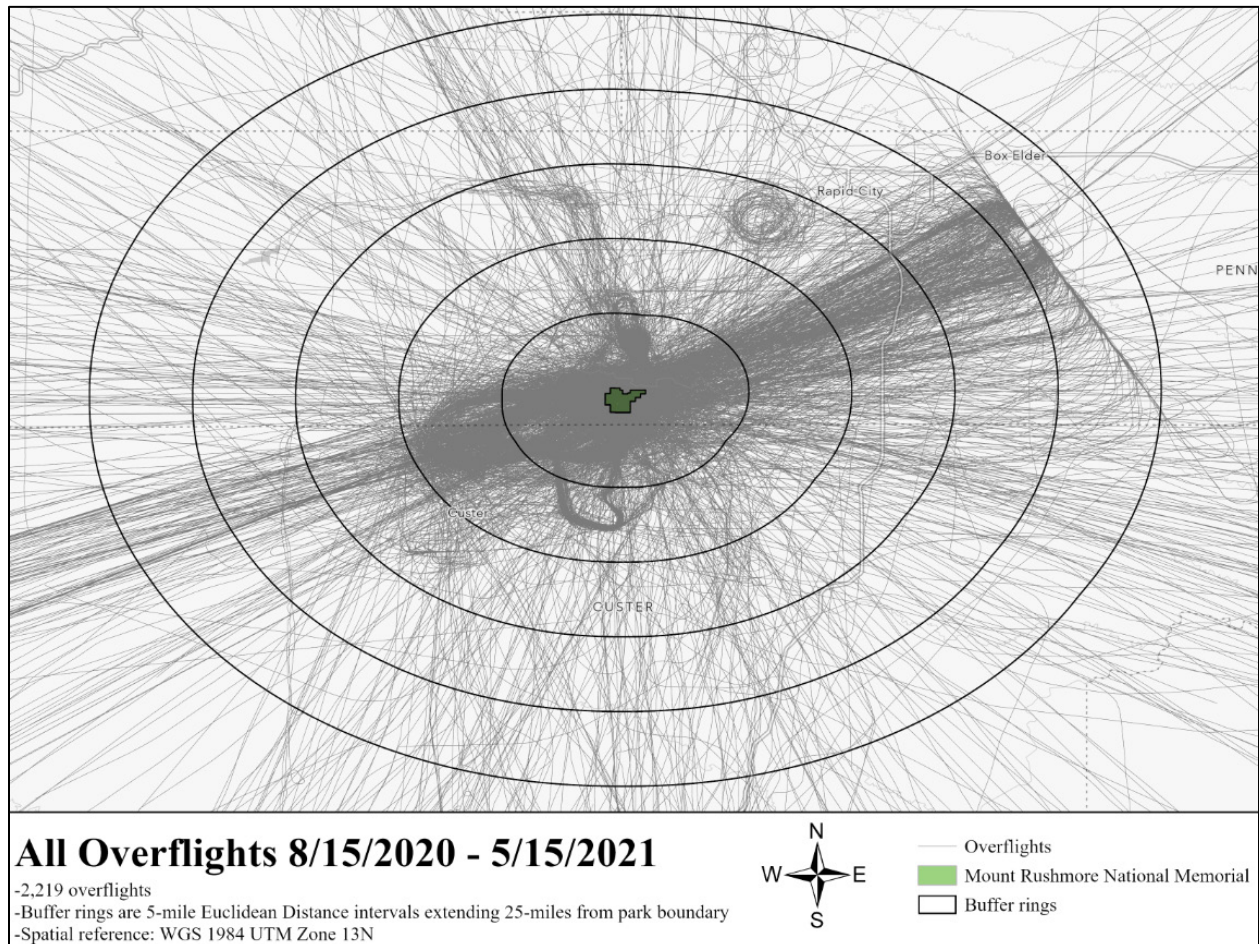


Figure 1. Map of all overflights extending 25 miles from the Mount Rushmore perimeter (flight tracks are black color with a line width of 0.3pt and a transparency of 50%).

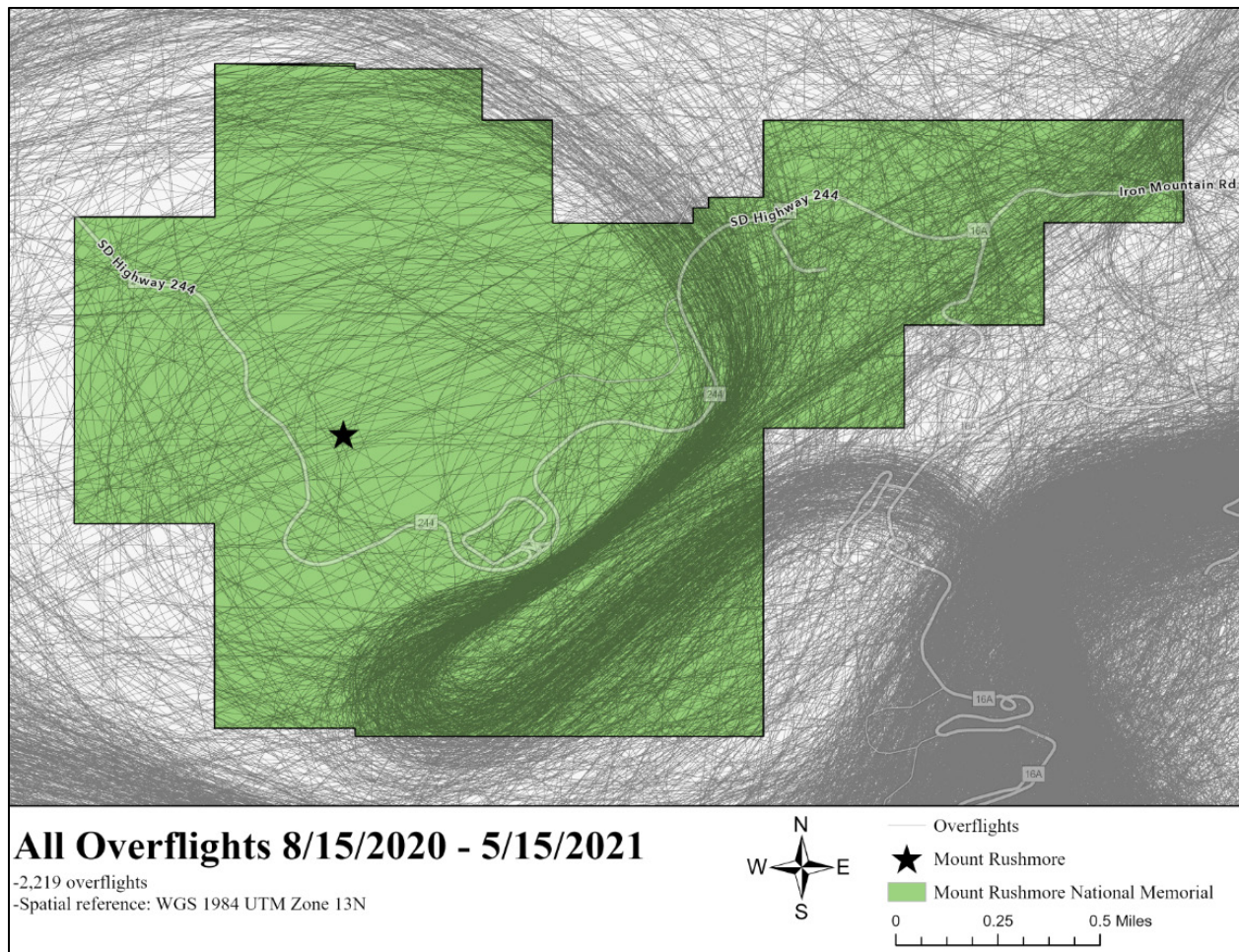


Figure 2. Map of all overflights above Mount Rushmore (flight tracks are black color with a line width of 0.3pt and a transparency of 50%).

Results – Phase 2

The researcher mapped low-level overflights that flew below 9,000ft MSL regardless of flight type. Figure 3 shows low-level overflights extending 10-miles from the Mount Rushmore perimeter. This figure shows a flight path ring around Mount Rushmore. Figure 4 displays this flight ring around Mount Rushmore, which is a zoomed in version of Figure 3, in addition to the pattern of flights directly over the southeast corner of Mount Rushmore. Figure 5 shows these same low-level overflights directly above Mount Rushmore.

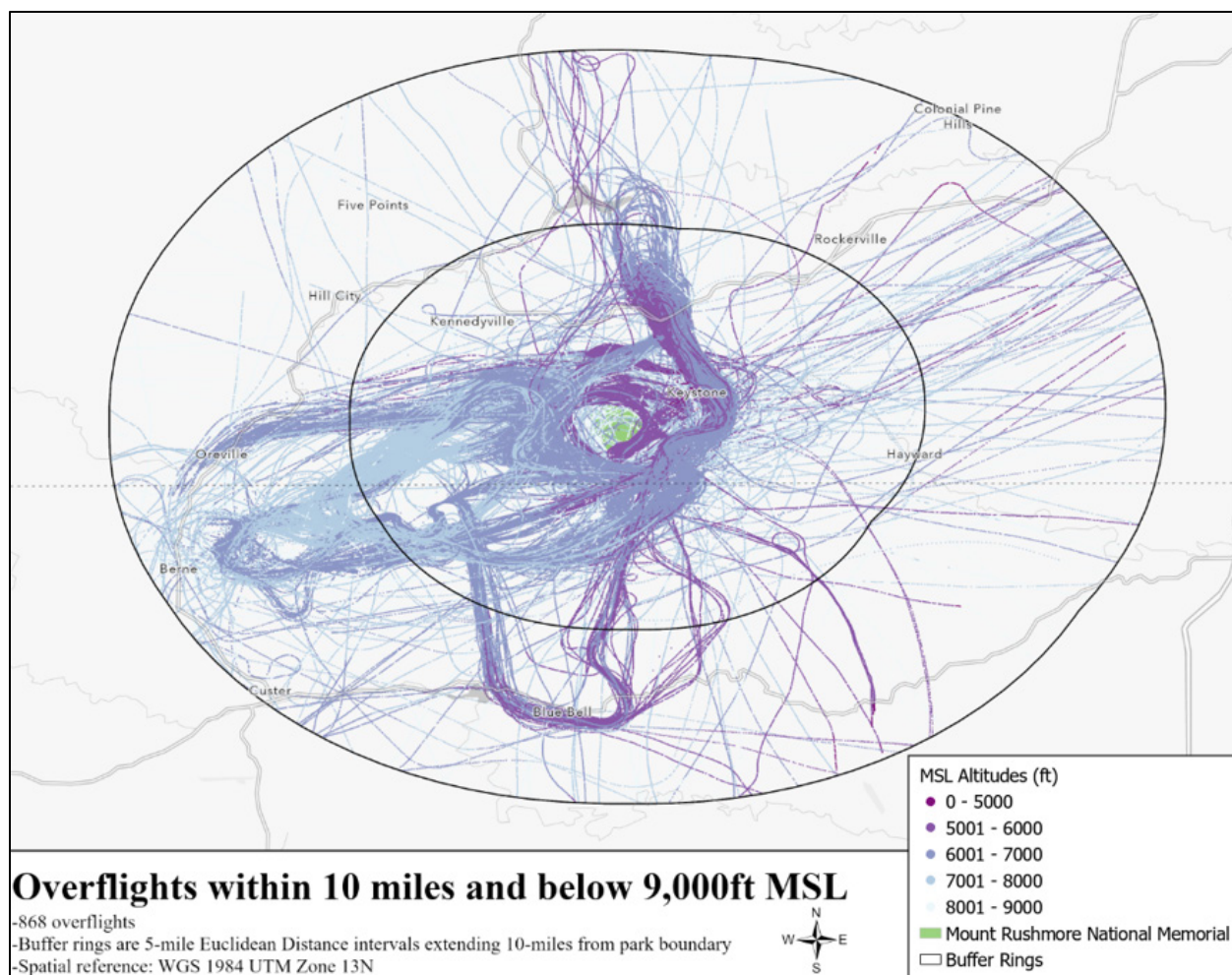


Figure 3. Low-level overflights within 10-miles of Mount Rushmore.

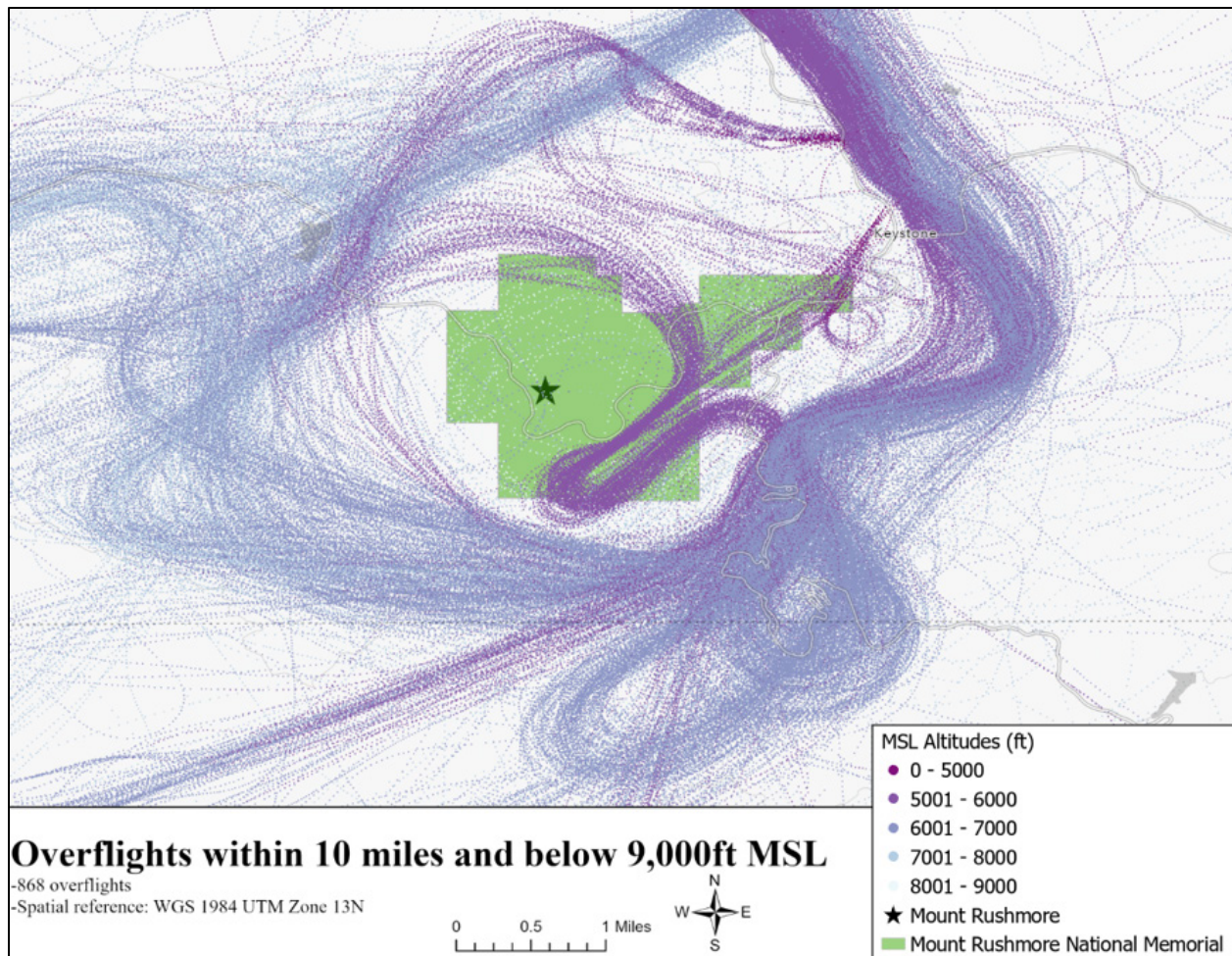


Figure 4. Low-level overflight ring-pattern around Mount Rushmore.

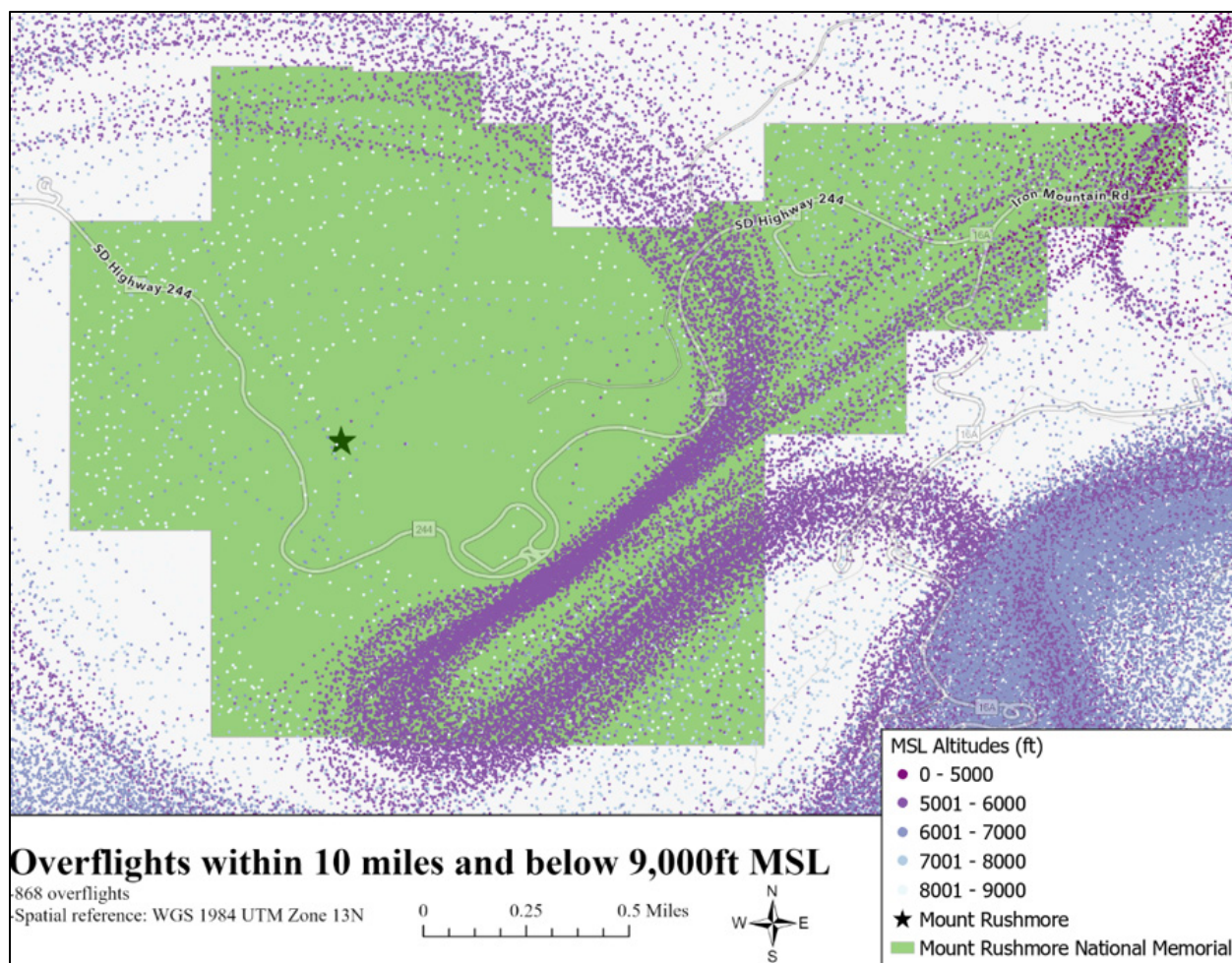


Figure 5. Low-level overflights above Mount Rushmore.

Results – Phase 3

Data were cleaned for civil patrol flights, survey flights, and flights with straight-line paths, which resulted in the following numbers of flights removed: 35 civil patrol flights, 4 survey flights, and 345 flights with straight-line paths. Point density analysis was conducted across AGL altitude intervals. The AGL altitude interval that showed the most density was 1,000-1,500ft (Figure 6). The density outputs were statistically compared using a correlation test. The altitude intervals with the highest correlation were 1,000-1,500ft AGL and 1,500-2,000ft AGL (Table 1).

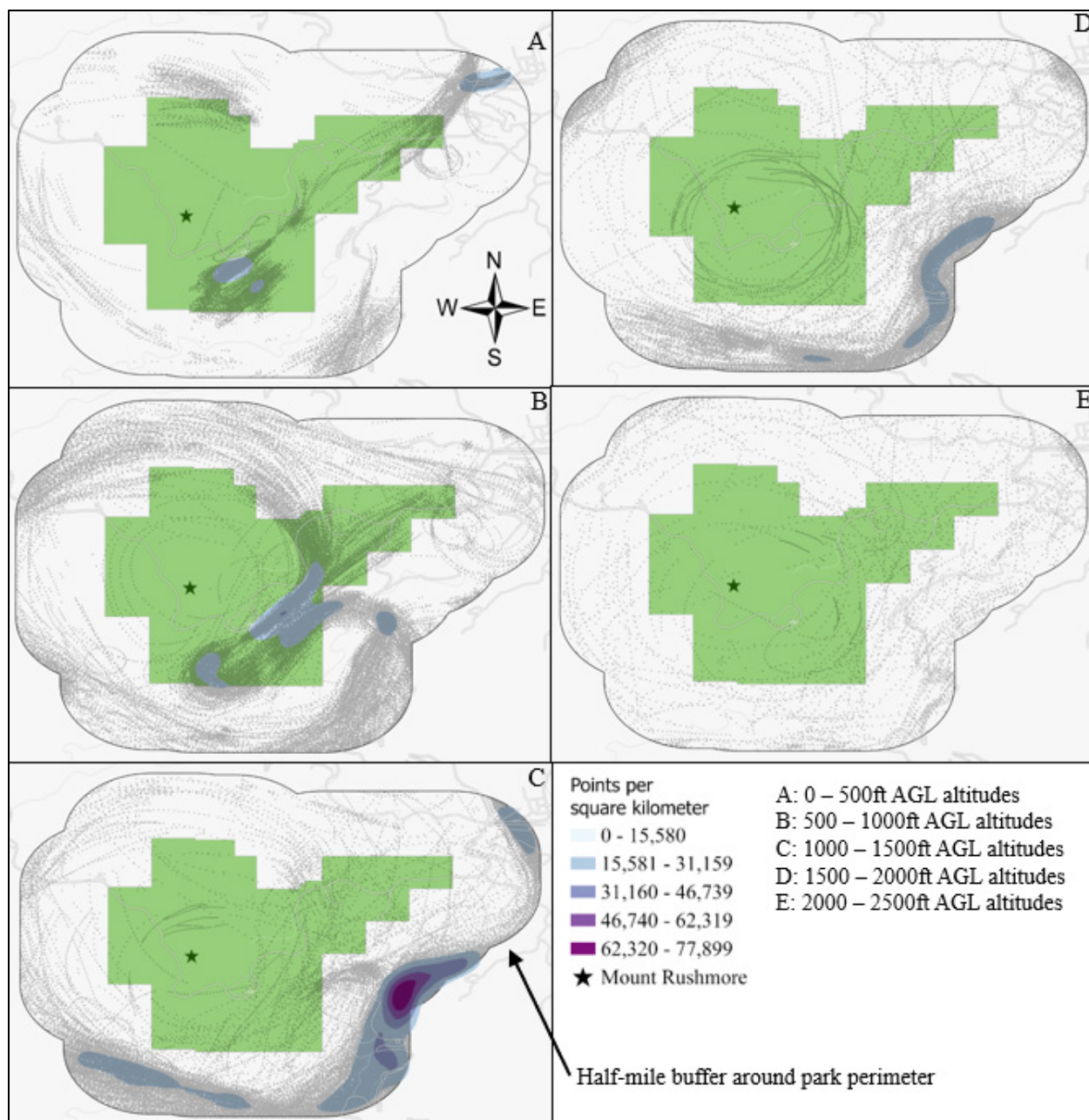


Figure 6. Point density analysis across AGL altitude intervals.

To further understand altitude trends of waypoints, two visualizations were produced. Figure 7 displays AGL altitude trends directly above Mount Rushmore and shows waypoint altitudes were mostly below 2,000ft AGL. Figure 8 displays MSL altitude trends directly above Mount Rushmore and shows waypoint trends were mostly below 7,500ft MSL. The information displayed in Figures 7 and 8 were inputted into tables to quantitatively understand which altitude intervals had the highest percentage of waypoints (181,711 waypoints were analyzed). Two AGL altitude intervals received a high percentage of waypoints: 500-1,000ft and 1,000-1,500ft (Table 2). Two MSL altitude intervals received a high percentage of waypoints: 5,500-6,000ft and 6,000-6,500ft (Table 3).

Table 1. Spatial correlation matrix of Above Ground Level (AGL) altitude point densities.

AGL Altitude Interval	1.	2.	3.	4.
1. 0-500ft AGL	–	–	–	–
2. 500-1,000ft AGL	0.28	–	–	–
3. 1,000-1,500ft AGL	0.06	0.26	–	–
4. 1,500-2,000ft AGL	0.05	0.25	0.87	–
5. 2,000-2,500ft AGL	0.09	0.30	0.52	0.63

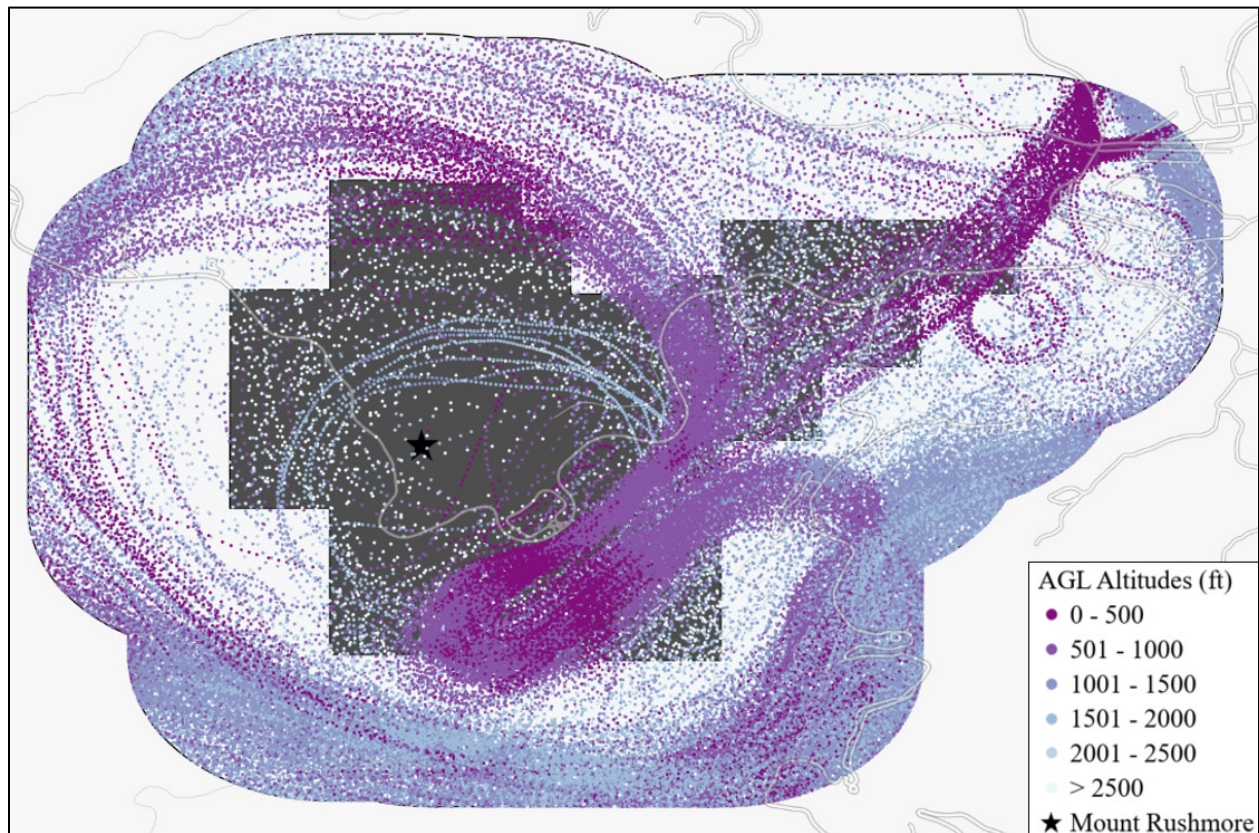


Figure 7. AGL altitude trends of waypoints with 0.5 mile of Mount Rushmore boundary ($n=181,711$ waypoints).

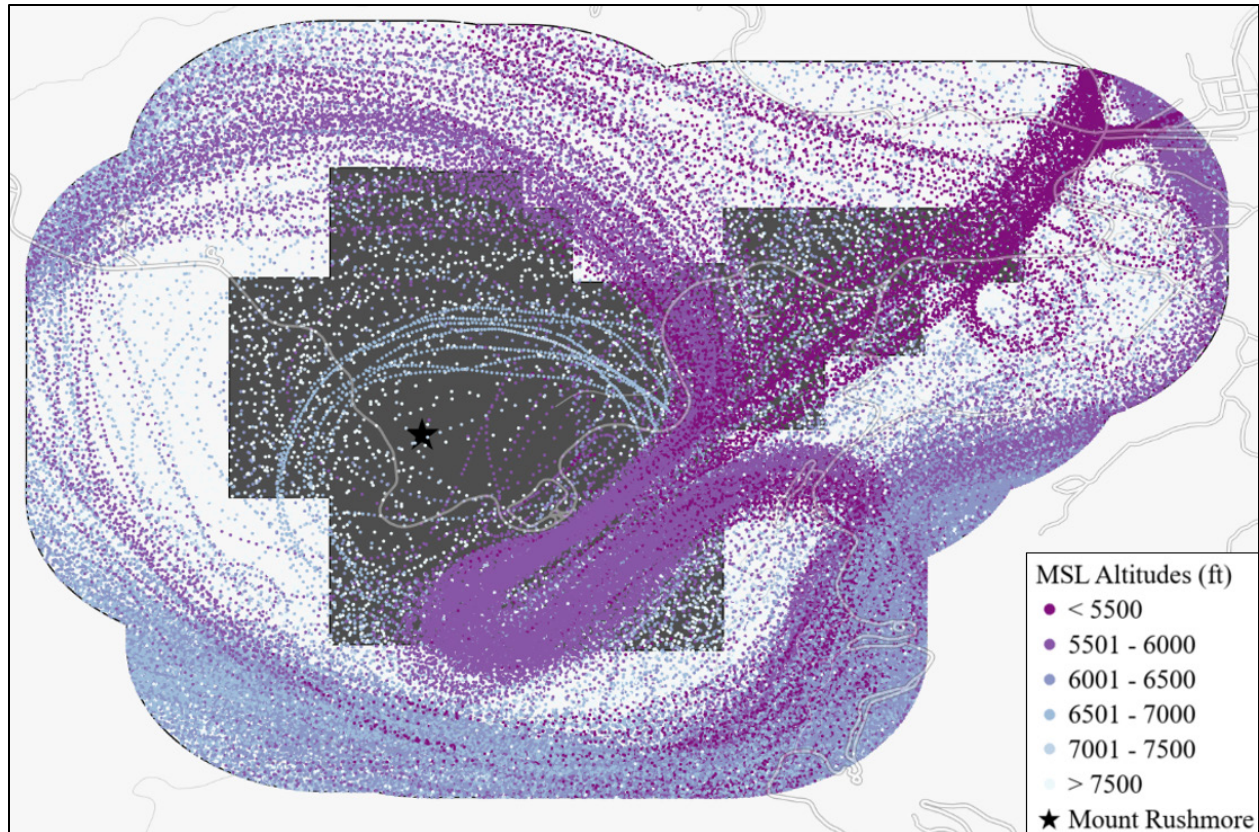


Figure 8. MSL altitude trends of waypoints with 0.5 mile of Mount Rushmore boundary ($n=181,711$ waypoints).

Table 2. Number and percentage of waypoints across AGL altitude intervals ($n=181,711$).

AGL altitude	Number of waypoints	Percentage of waypoints
0-500ft	19,505	10.73
500.01-1,000ft	45,965	25.30
1,000.01-1,500ft	67,000	36.87
1,500.01-2,000ft	29,685	16.34
2,000.01-2,500ft	5,431	2.99
2,500.01-3,000ft	5,102	2.81
3,000.01-3,500ft	4,892	2.69
3,500.01-4,000ft	1,464	0.81
4,000.01-4,500ft	646	0.36
>4,500ft	2,021	1.11

Table 3. Number and percentage of waypoints across MSL altitude intervals ($n=181,711$).

MSL altitude	Number of waypoints	Percentage of waypoints
0-4500ft	1,124	0.62
4500.01-5,000ft	5,499	3.03
5,000.01-5,500ft	15,903	8.76
5,500.01-6,000ft	63,457	34.95
6,000.01-6,500ft	56,097	30.90
6,500.01-7,000ft	21,865	12.04
7,000.01-7,500ft	4,649	2.56
7,500.01-8,000ft	7,502	4.13
8,000.01-8,500ft	2,202	1.21
8,500.01-9000ft	1,369	0.75
>9,000ft	1,875	1.03

Overflight maps were constructed for the five aircraft owners who conducted the most rotorcraft flights. The following maps show the overall flight routes for Emerald City Aircraft Leasing Inc (Figure 9), Tag Aviation Inc (Figure 10), Higgins Leasing Inc (Figure 11), Langbehn Land and Cattle Co Inc (Figure 12), and Black Hills Helicopters Inc (Figure 13). Emerald City Aircraft Leasing Inc conducted 799 overflights (tail number N74767), Tag Aviation Inc conducted 332 overflights (tail numbers N382SP and N407TF), Higgins Leasing Inc conducted 226 overflights (tail numbers N6636, N838GG, N4034H, and N5860H), Langbehn Land and Cattle Co Inc conducted 10 overflights (tail number N456ML), and Black Hills Helicopters Inc conducted 4 overflights (tail number N605BH). Next, an analysis of AGL altitude waypoint distribution was conducted for each aircraft owner for waypoints within a half-mile of the Mount Rushmore perimeter. Each of these owners showed mean and median altitudes to be below 1,600ft AGL (Figures 14-18).

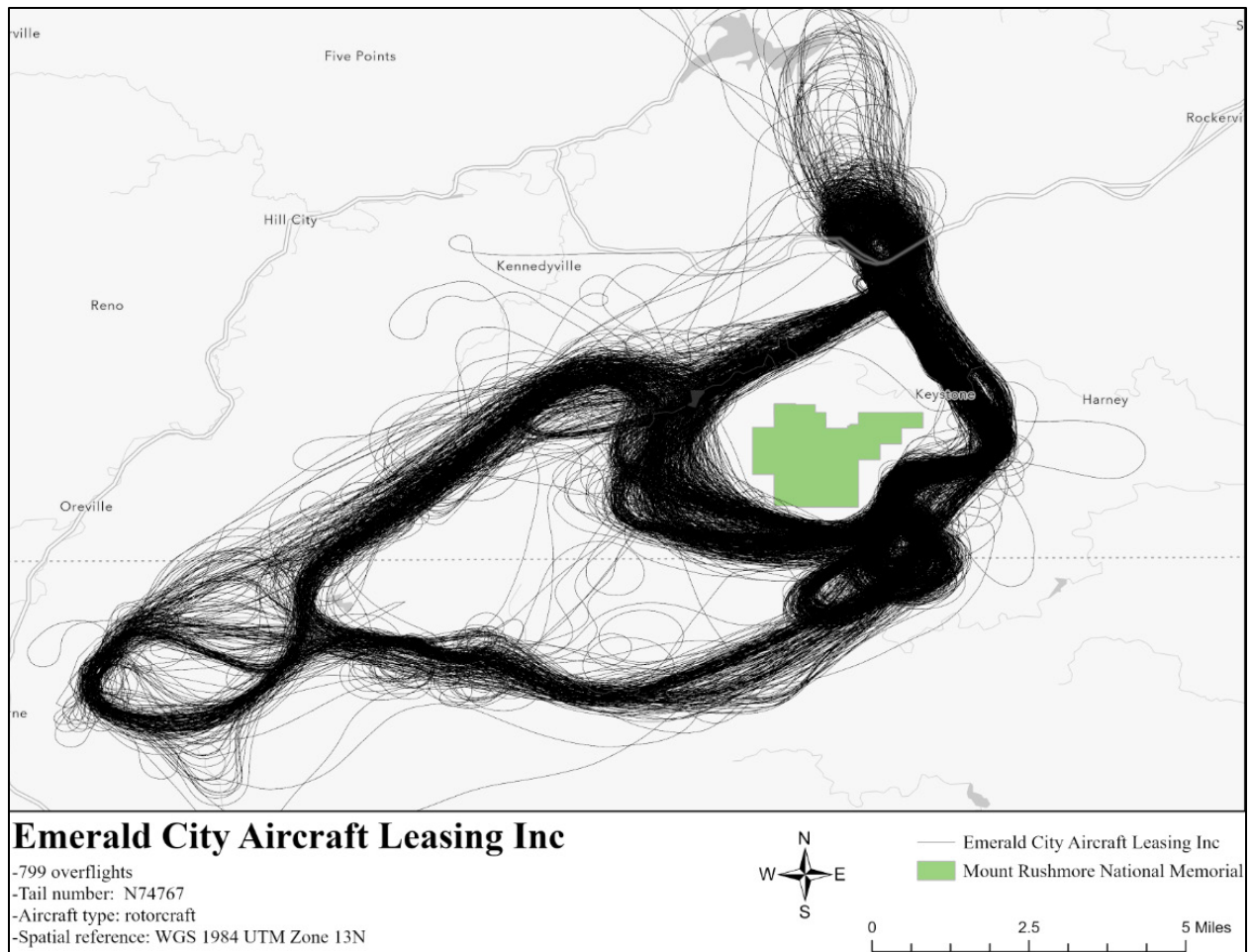


Figure 9. Emerald City Aircraft Leasing Inc flight routes.

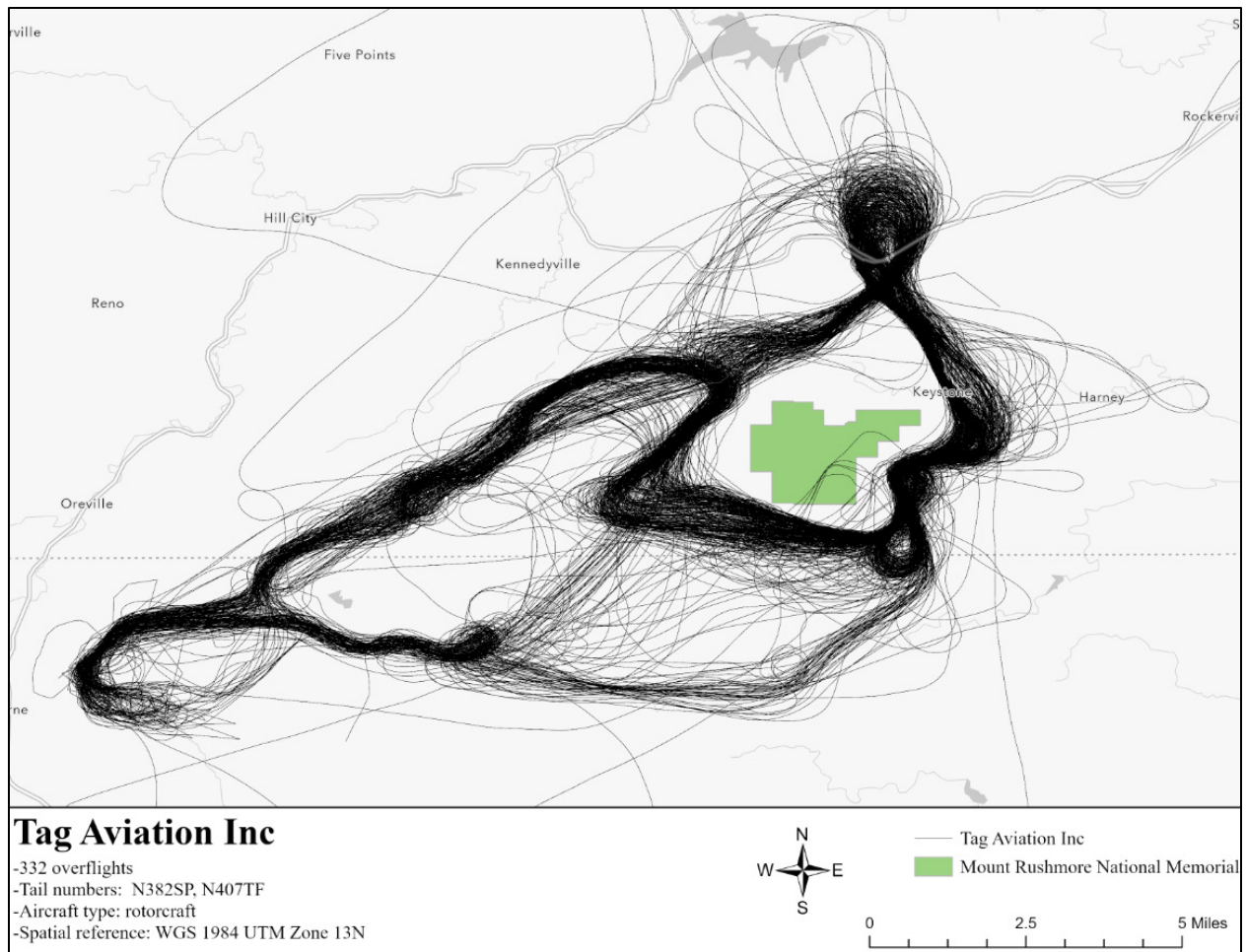


Figure 10. Tag Aviation Inc flight routes.



Figure 11. Higgins Leasing Inc flight routes.

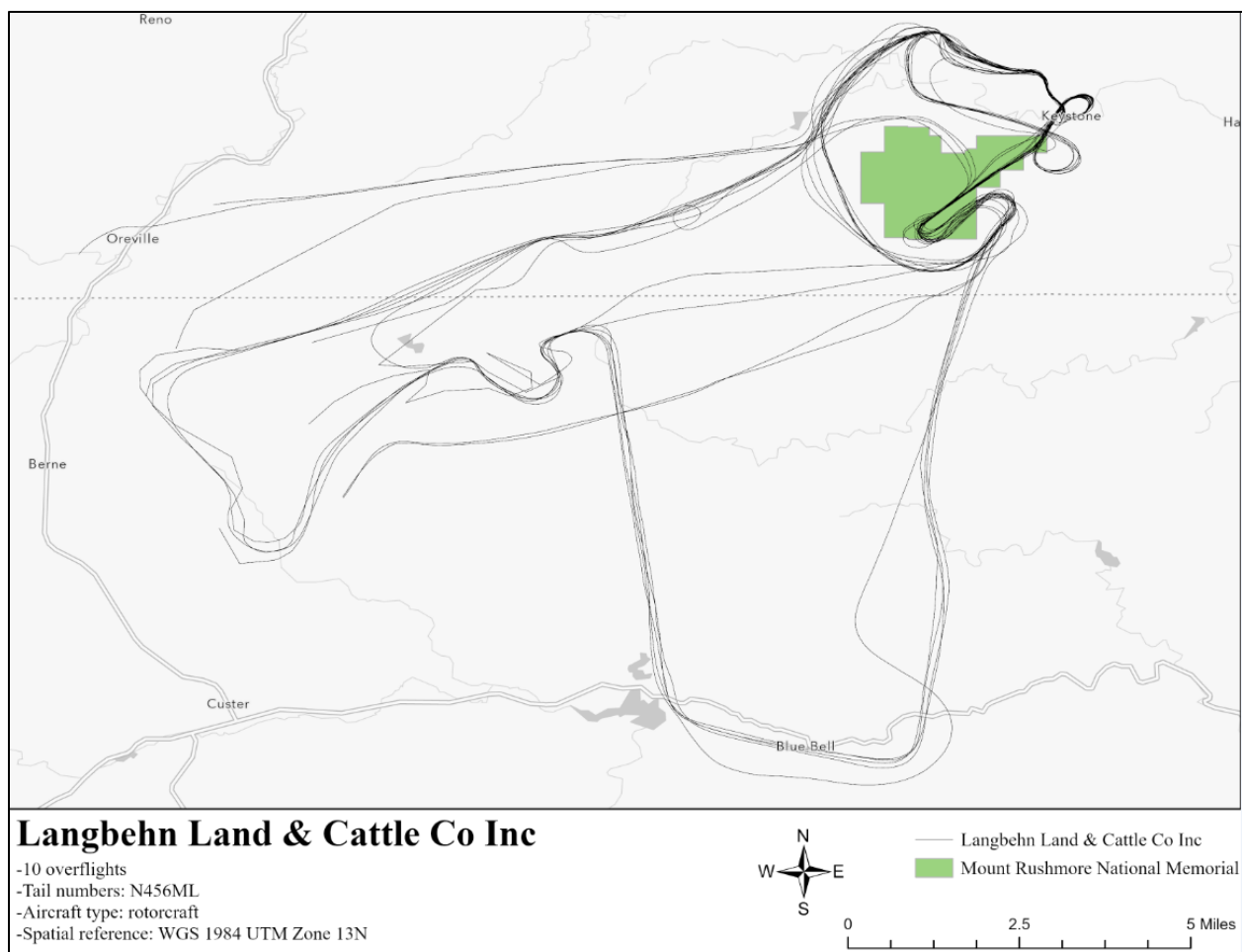


Figure 12. Langbehn Land and Cattle Co Inc flight routes.

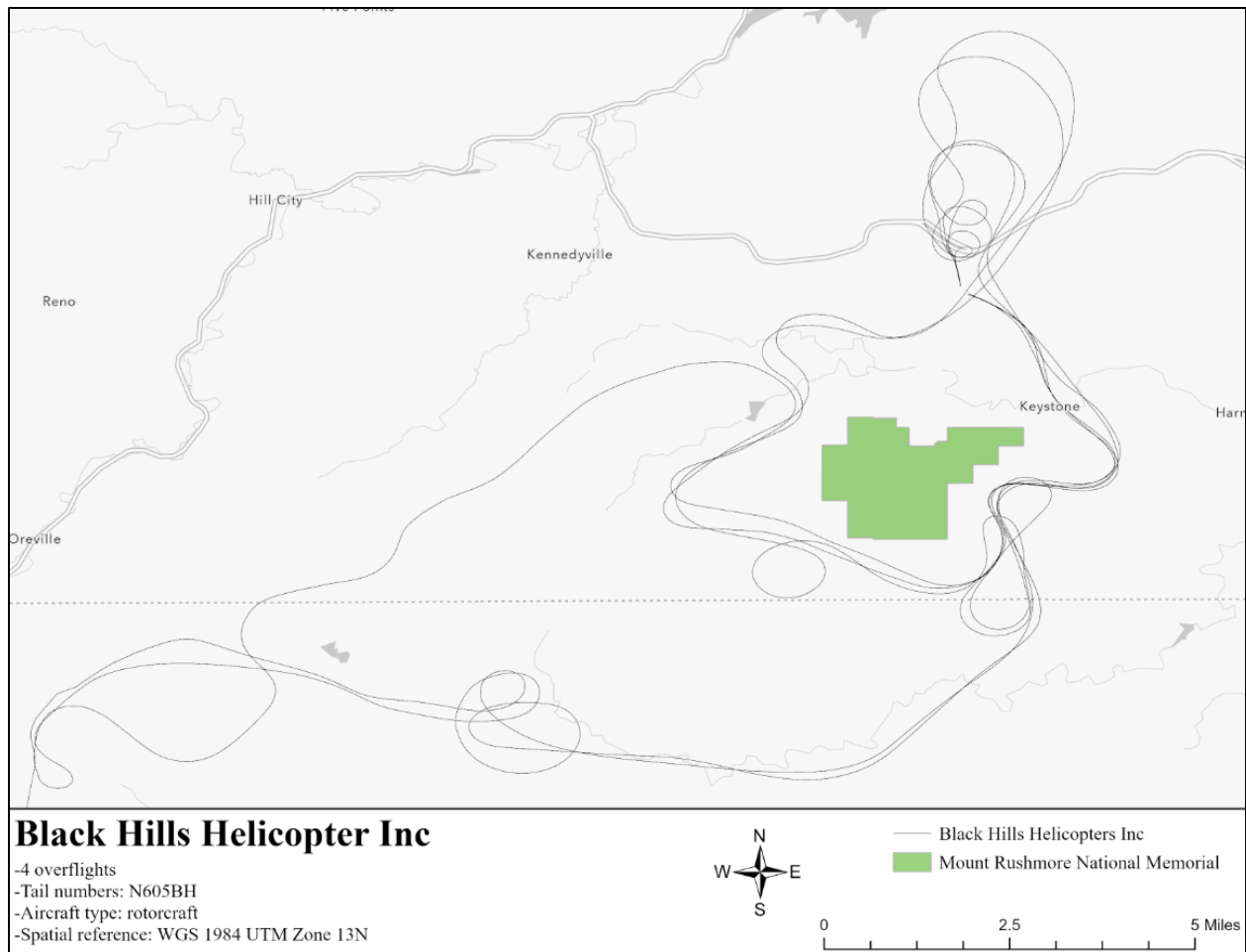


Figure 13. Black Hills Helicopters Inc flight routes.

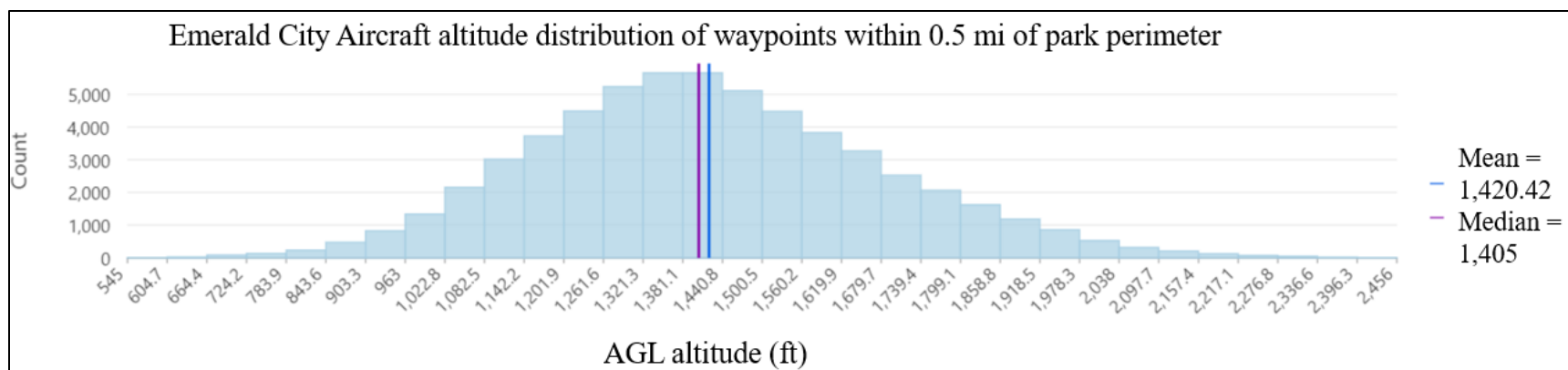


Figure 14. Emerald City Aircraft Leasing Inc altitude distribution that ranged from 545 to 2,456ft AGL.

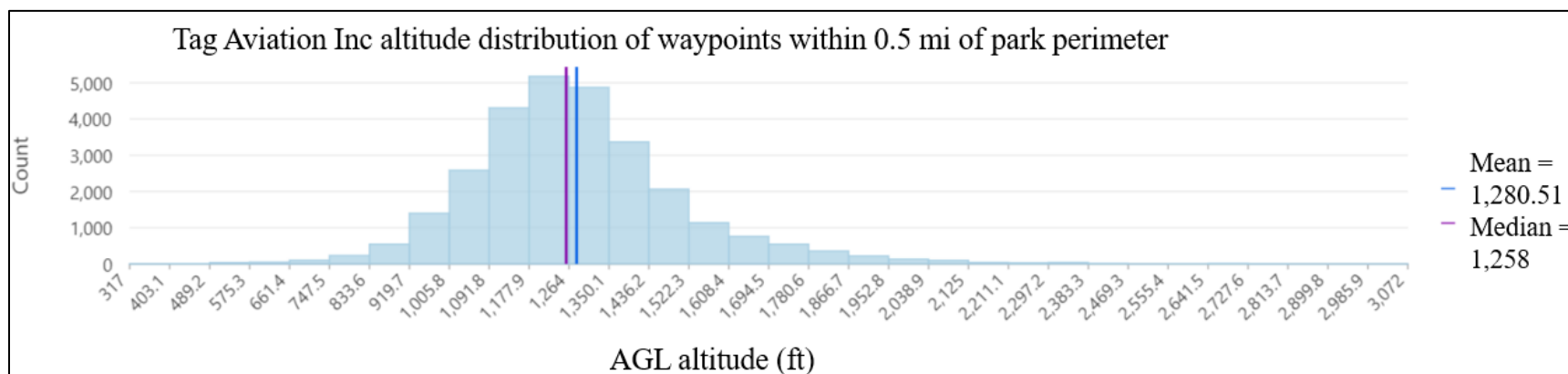


Figure 15. Tag Aviation Inc altitude distribution that ranged from 317 to 3,072ft AGL.

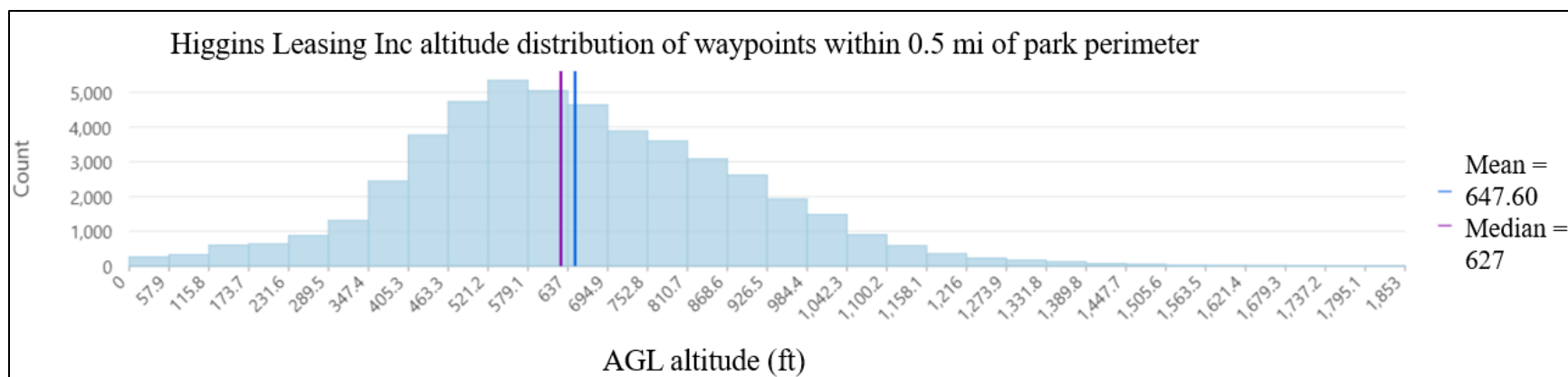


Figure 16. Higgins Leasing Inc altitude distribution that ranged from 0 to 1,853ft AGL.

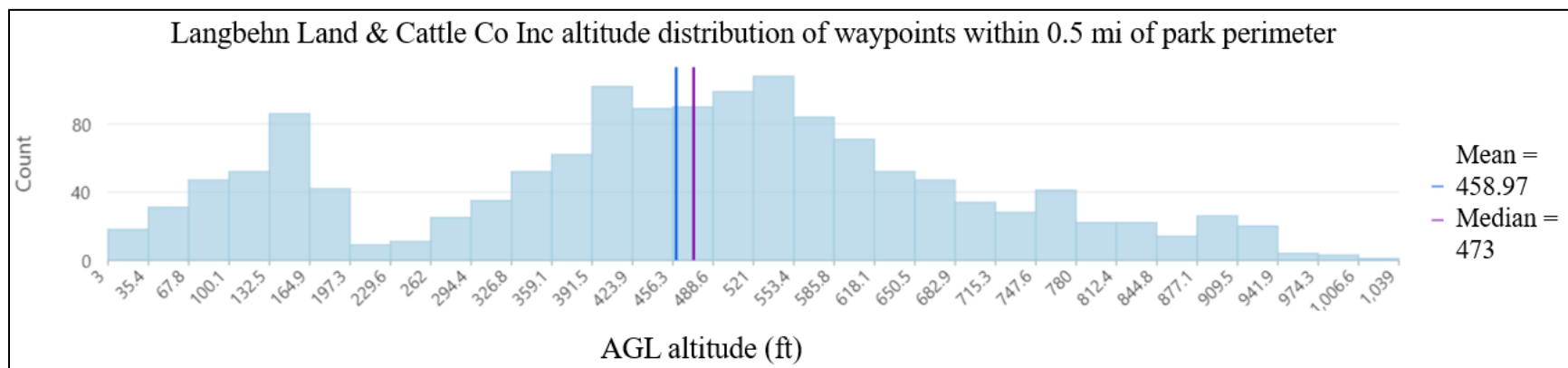


Figure 17. Langbehn Land and Cattle Co Inc altitude distribution that ranged from 3 to 1,039ft AGL.

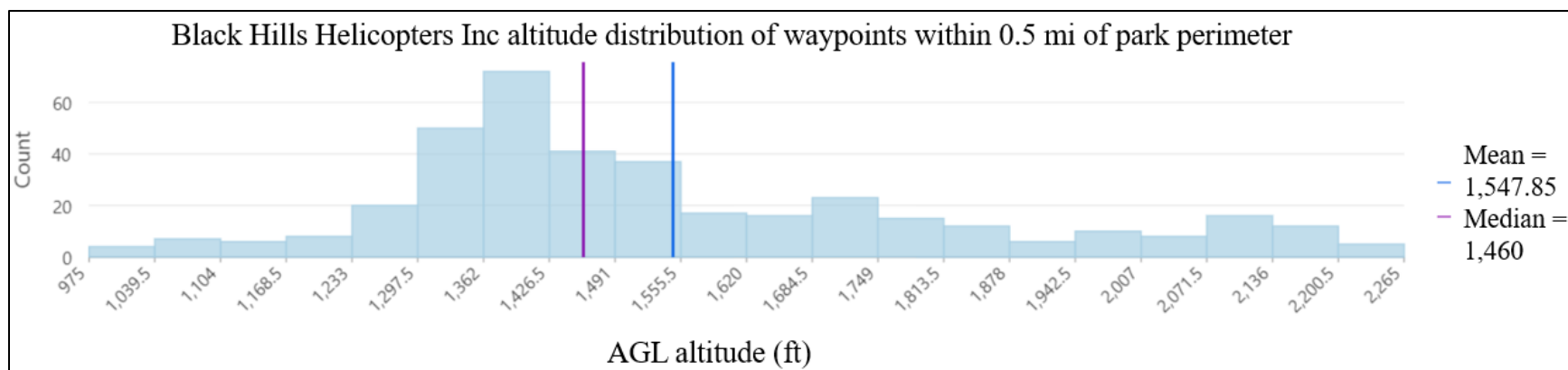


Figure 18. Black Hills Helicopters Inc altitude distribution that ranged from 975 to 2,265ft AGL.

Lastly, overflights were analyzed across months, days of the week, and hours of the day (total flights analyzed = 1,815). Table 4 shows number of days air tour data were collected, overflights per month, average number of flights per day for the data collection duration, which occurred from August 15th of 2020 to May 15th of 2021. Mount Rushmore received the most overflights during August (average number of daily flights was 23.19) and September (average number of daily flights was 24.47). Figure 19 shows average numbers of flights across days of the week. The most overflights occurred on Fridays (average number of flights was 11.29), Saturdays (average number of flights was 13.22), and Sundays (average number of flights was 10.76). Table 5 shows number and percentage of overflights per hour across weekdays (Monday through Friday) and weekends (Saturday, Sunday, and holidays). Mount Rushmore receives the most overflights during the hours of 9:00am to 4:00pm.

Table 4. Number of overflights across months ($n=1,815$)*

Month	Number of days air tours were recorded	Number of overflights	Average number of overflights per day
August 2020*	16	371	23.19
September 2020	30	734	24.47
October 2020	26	280	10.77
November 2020	20	60	3.00
December 2020	20	45	2.25
January 2021	17	37	2.18
February 2021	9	12	1.33
March 2021	20	56	2.80
April 2021	22	66	3.00
May 2021*	15	154	10.27

* Air tours are weather dependent and the number of air tours decreases during weather events that could compromise flight safety and the ability to see the terrain, which results in less air tours in the winter. There is a busy (summer) and non-busy season for tourism in the Black Hills area. * For August of 2020, data collection began on August 15th; for May of 2021, data collection ended on May 15th.

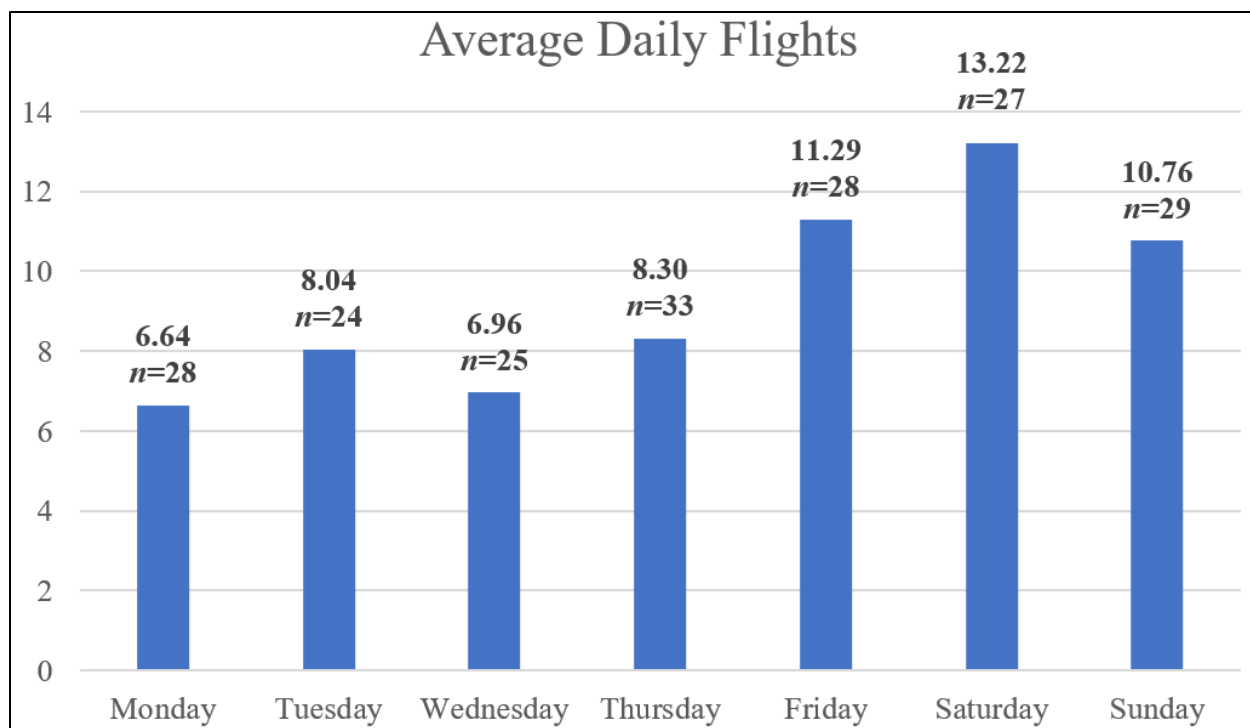


Figure 19. Average number of flights per day of the week.

Table 5. Number and percentage of overflights across hours of the day for weekdays ($n=1,146$) and weekends ($n=669$). Weekdays include Monday through Friday.

Hour	Number of overflights on weekdays	Percentage of overflights on weekdays	Number of overflights on weekends	Percentage of Overflights on weekends
6:00am-7:00am	1	0.09	1	0.15
7:00am-8:00am	15	1.31	3	0.45
8:00am-9:00am	21	1.83	15	2.24
9:00am-10:00am	129	11.26	79	11.81
10:00am-11:00am	161	14.05	77	11.51
11:00am-12:00pm	145	12.65	79	11.81
12:00pm-1:00pm	127	11.08	71	10.61
1:00pm-2:00pm	122	10.65	75	11.21
2:00pm-3:00pm	132	11.52	80	11.96
3:00pm-4:00pm	104	9.08	68	10.16
4:00pm-5:00pm	91	7.94	51	7.62
5:00pm-6:00pm	72	6.28	53	7.92

Table 5 (continued). Number and percentage of overflights across hours of the day for weekdays ($n=1,146$) and weekends ($n=669$). Weekdays include Monday through Friday.

Hour	Number of overflights on weekdays	Percentage of overflights on weekdays	Number of overflights on weekends	Percentage of Overflights on weekends
6:00pm-7:00pm	23	2.01	17	2.54
7:00pm-8:00pm	3	0.26	0	0.00

Discussion

The purpose of this study was to explore the spatial and temporal patterns of overflights at Mount Rushmore. Flight tracking data were analyzed from August 15th, 2020 to May 15th, 2021 and included 2,219 overflights. Analysis consisted of three phases.

The first phase focused on all overflights and showed a concentrated trend of overflights above Mount Rushmore. Visual analysis of these data suggest most overflights were low-level flights rather than a concentration of traffic at high altitudes.

The second phase focused on low-level overflights and showed low-level overflights fly in a ring-shaped formation around Mount Rushmore and trend along the southeast corner of the park. Further, this phase also revealed that low-level flights (mostly air tours) sightsee at many locations in the area, not only Mount Rushmore with many venturing up to 15 miles away from Mount Rushmore.

The third phase focused on air tours by removing flights known to not be air tours. The dataset was cleaned of 35 civil patrol flights, 4 survey flights, and 345 flights with straight-line paths. It was found that overflight density was the highest for the altitude interval of 1,000-1,500ft AGL, which also had the most waypoints of the analyzed altitude intervals. Additionally, it was shown that Higgins Leasing Inc and Langbehn Land and Cattle Co Inc fly over the park while Emerald City Aircraft Leasing Inc, Tag Aviation Inc, and Black Hills Helicopter Inc fly in a ring-shaped pattern around Mount Rushmore. All five rotorcraft owners that were analyzed had mean and median altitudes below 1,600ft AGL. This concentration of flights below 2,000ft AGL has implications for the acoustic environment at the park.

In conclusion, this study produced results to further understand overflights at Mount Rushmore. This information can be used for planning and management purposes. This study serves as a resource for future research that intends to use more advanced analytics.

Literature Cited

- Beeco, J. A. & Joyce, D. 2019. Automated aircraft tracking for park and landscape planning. *Landscape and Urban Planning* 186, 103-111.
- Beeco, J. A., Joyce, D., & Anderson, S. 2020. Evaluating the use of spatiotemporal aircraft data for air tour management planning and compliance. *Journal of Park and Recreation Administration*, 39(1).
- FAA. 2018. ADS-B, Research, Airspace. Available at:
<https://www.faa.gov/nextgen/equipadsb/research/airspace/>
- FAA. 2020. Airspace. Available at: <https://www.faa.gov/nextgen/equipadsb/research/airspace/>
- FAA. 2021. Aircraft Registration. Available at:
https://www.faa.gov/licenses_certificates/aircraft_certification/aircraft_registry/releasable_aircraft_download/
- National Park Service. 2021. Air Tours. Available at:
<https://www.nps.gov/subjects/sound/airtours.htm>
- Poluga, S. L., & Shakoar, A. 2019. Rock Mass Characterization of Mount Rushmore National Memorial, Keystone, South Dakota. In *IAEG/AEG Annual Meeting Proceedings*, San Francisco, California, 2018-Volume 1 (pp. 3-9). Springer, Cham.
- United States Geological Survey. 2021. The National Map – Data Delivery. Available at:
<https://www.usgs.gov/core-science-systems/ngp/tnm-delivery>

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 323/181617, June 2022

National Park Service
U.S. Department of the Interior



[Natural Resource Stewardship and Science](#)

1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525