



Analyses of Quiet Technology Seasonal Relief Incentives for Grand Canyon National Park

Combined Annual Reports for 2015–2018

Natural Resource Report NPS/GRCA/NRR—2022/2414



ON THE COVER

Scientists in Parks interns collect data at an acoustic monitor station along the North Rim of Grand Canyon National Park, Arizona.

NPS/HANNAH CHAMBLESS

Analyses of Quiet Technology Seasonal Relief Incentives for Grand Canyon National Park

Combined Annual Reports for 2015–2018

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June 2022

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

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Please cite this publication as:

Rapoza, A. S., D. R. Joyce, V. L. Ward, and C. Lee. 2022. Analyses of quiet technology seasonal relief incentives for Grand Canyon National Park: Combined annual reports for 2015–2018. Natural Resource Report NPS/GRCA/NRR—2022/2414. National Park Service, Fort Collins, Colorado. <https://doi.org/10.36967/nrr-2292977>.

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Executive Summary

This report describes the legislative background, modeling process, and annual results used by the National Park Service (NPS) and the Federal Aviation Administration (FAA) in order to meet the requirements of the National Parks Overflights Act of 1987 (Public Law 100-91), the National Parks Air Tour Management Act of 2000 (NPATMA, Public Law 106-181) and the Moving Ahead for Progress in the 21st Century Act of 2012 (MAP-21, Public Law 112-141) regarding the substantial restoration of natural quiet at Grand Canyon National Park. MAP-21 requires all commercial air tour aircraft operating within the Grand Canyon National Park Special Flight Rules Area convert to quiet aircraft technology (QT) within 15 years (i.e., by 2027). MAP-21 also requires the FAA and NPS to provide incentives for commercial air tour operators that convert to QT prior to the statutory mandate. Pursuant to NPATMA, the cumulative impact of providing incentives, such as increasing flight allocations for QT, must not increase noise at Grand Canyon and must not diminish the achievement of substantial restoration of natural quiet that was called for in the Overflights Act.

On January 1, 2015, the agencies implemented a QT incentive for commercial air tour operators consistent with both MAP-21 and NPATMA. The incentive provides seasonal relief during the first quarter (January–March) from allocations for commercial air tour operators that utilized QT aircraft in the popular Dragon and Zuni Point corridors. During the first quarter, QT air tours did not need to use an allocation, while non-quiet technology air tours still required the use of an allocation. The allocations that operators would have been required to use during the first quarter (“saved” allocations) can then be flown within the corridors during other times of the year.

The NPS and FAA developed a methodology to ensure the incentive complies with the statutory mandates for not increasing noise at Grand Canyon and not diminishing the achievement of substantial restoration of natural quiet. Beginning in 2015, the agencies have modeled each year’s commercial tours flown in the Dragon and Zuni Point corridors. This report summarizes the annual air tour reporting data, use of QT, and results of the modeling for cumulative noise and substantial restoration of natural quiet for years 2015–2018. Key results include:

- Quiet technology incentives appear to increase QT usage during the seasonal relief period—the first quarter of the year. Quiet technology usage is greatest in the first quarter, averaging 86%, and then drops in the second through fourth quarters. Quiet technology usage is lowest in the third quarter when total flights are highest.
- Modeled annual noise exposure through 2018 has not exceeded the 2012 baseline level. However, the annual noise exposure has closely approached the baseline level.

The substantial restoration of natural quiet has not been diminished. The area of the park free of noise for 75% of the day has not dropped below 50%. During days of peak activity, the percentage of park area free of noise for 75% of the day has ranged from 62–67%. The NPS and FAA will continue annual evaluation of seasonal relief incentives through modeling of annual noise exposure in the Dragon and Zuni Point corridors, as well as the achievement of substantial restoration of natural quiet through modeling of audibility duration throughout the park.

1. Introduction

In February of 1919, the first recorded Grand Canyon air tour took place. It is amazing to consider that it only took 16 years from the first flight in history to an air tour over Grand Canyon. Six months later, Grand Canyon National Monument was designated as a national park, shown in Figure 1. In 1927 an air tour company began operations for air tours over Grand Canyon. Over the years, the number of tours soared and paved the way for the construction of the Grand Canyon Airport in 1967 in Tusayan, Arizona. As the number of air tours grew, so did concerns about effects of noise on park resources and visitor experience. Since the 1970s, Congress has passed a series of laws with the intent of mitigating noise from the busiest airspace for air tours over any National Park System unit. The most recent law passed in 2012 requires the National Park Service (NPS) and the Federal Aviation Administration (FAA) to provide incentives to operators who convert to quiet aircraft technology before 2027, provided the cumulative impact of such operations does not increase noise at Grand Canyon and meets the standard of “substantial restoration of natural quiet.” This document describes the legislative background, modeling process, and annual results used by the NPS and FAA in supporting the seasonal relief quiet technology (QT) incentive and the substantial restoration of natural quiet (SRNQ) for Grand Canyon National Park. A detailed chronology of significant events pertaining to Grand Canyon overflights can be found on the NPS Grand Canyon website (https://www.nps.gov/grca/learn/nature/airoverflights_chrono.html).

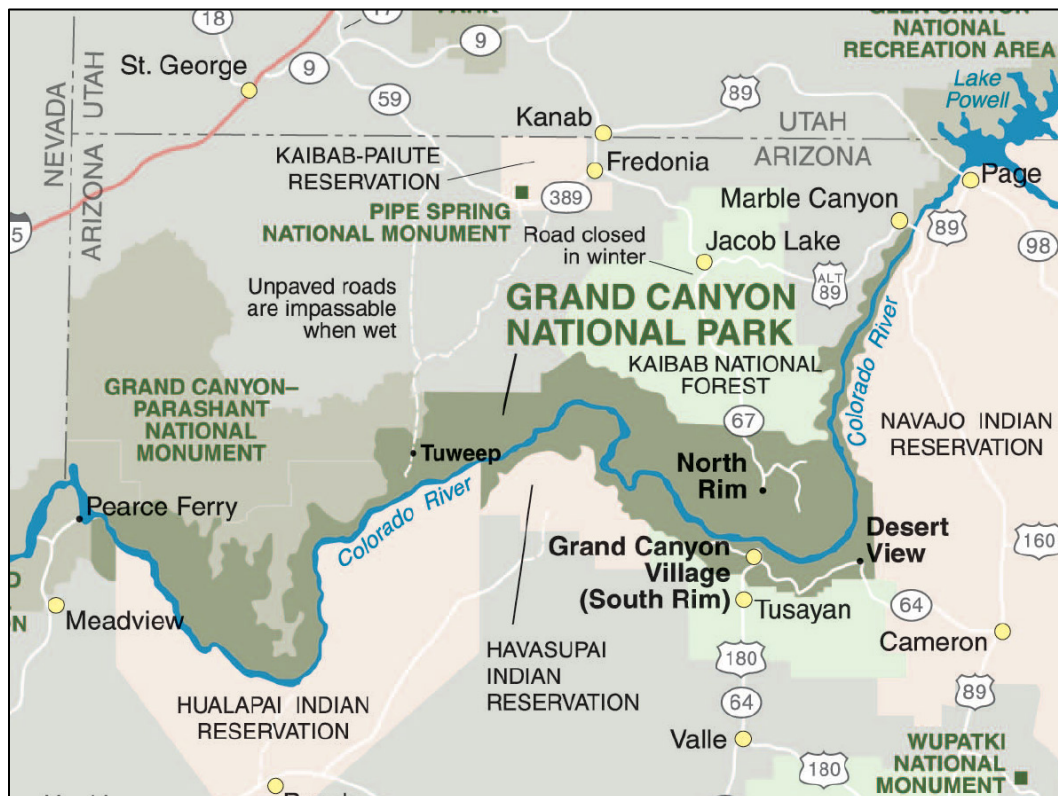


Figure 1. Map of Grand Canyon National Park and surrounding area.

Up until the 1970s, there was little regulation of overflights, and air tours were flying throughout the park and below the rim in certain areas. In the Grand Canyon National Park Enlargement Act of 1975 (Public Law No. 93-620), Congress required the Department of Interior to consider how to manage air tours to preserve acoustic conditions and natural quiet of the park. In June 1986, a mid-air collision between two air tour flights resulted in 25 fatalities and brought national attention to the issue of overflights at National Park System units. This led to the designation of a Special Flight Rules Area (SFRA) for Grand Canyon National Park in March 1987 (SFAR 50-2, 14 Code of Federal Regulations Part 93 Subpart U), and the passing of the National Parks Overflights Act (Public Law 100-91) in August 1987. A major provision of the Overflights Act required the Department of the Interior to submit to the FAA recommendations “regarding actions necessary for the protection of resources in the Grand Canyon from adverse impacts associated with aircraft overflights” and required that the recommendations “provide for the substantial restoration of the natural quiet and experience of the park and protection of public health and safety from adverse effects associated with aircraft overflight.” The Act also required the Department of Interior to submit a report to Congress on whether the Special Flight Rules Area had successfully restored natural quiet in the park. The “Report on Effects of Aircraft Overflights on the National Park System” (NPS 1995) recommended numerous revisions to SFAR 50-2 and defined “substantial restoration of natural quiet” as “50% or more of the park achieving natural quiet (i.e., no aircraft audible) for 75% to 100% of the day.”

In response to the recommendations, from 1996 to 2000, the FAA modified SFAR 50-2 several times which created flight-free zones and specific flight corridors and routes for air tours and general aviation flights (see Figure 2)¹. The FAA also issued a rule that limited the number of commercial air tour operations that may be conducted in the Grand Canyon Special Flight Rules Area (65 Federal Register 17708). The National Parks Air Tour Management Act of 2000 (NPATMA, Public Law 106-81) reaffirmed the requirement to achieve substantial restoration of the natural quiet and experience at Grand Canyon and required the FAA to designate reasonably achievable requirements for aircraft to be considered quiet technology.

In 2005, the FAA issued the final rule that designated aircraft that meet specified noise criteria as quiet technology (70 Federal Register 16084-16093). The National Parks Air Tour Management Act also required that quiet aircraft technology air tours at Grand Canyon not be subject to flight allocations, provided cumulative impact does not increase noise at the park. Most recently, the Moving Ahead for Progress in the 21st Century Act of 2012 (MAP-21, Public Law 112-141) amended the 1987 Overflights Act by providing a new definition of substantial restoration of natural

¹ Detailed information regarding routes and flight altitudes can be found in the Grand Canyon National Park Special Flight Rules Area (GCNP SFRA) Procedure Manual https://www.faa.gov/about/office_org/field_offices/fsdo/las/media/SFRA_GCNP_Manual.pdf and the VFR (Visual Flight Rules) Aeronautical Charts https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/vfr/#grandCanyon available from FAA

Legend

- Points of Interest
- Airport/Airstrip
- Grand Canyon National Park

Air Tour Route

- Fixed-wing, Black Route
- Fixed-wing, Blue Route
- Helicopter
- Support

General Aviation Corridor (GAC)

- General aviation allowed above 10,499 ft MSL

Flight Free Zone (FFZ)

- No flights below 8,000 ft MSL
- No flights below 14,500 ft MSL

Special Flight Rules Area

- Restricted flights below 18,000 ft MSL

Map Labels:

- Lake Mead
- Pearce Ferry Airport
- Grand Canyon West Airport
- Grand Canyon Bar Ten Airstrip
- Whitmore Wash
- Toroweap Overlook
- Toroweap/Shinumo FFZ
- Kanab Point
- Sage Valley
- Fossil Canyon Corridor
- Point Sublime
- Tuckup Corridor
- Bright Angel FFZ
- Hermit Basin
- Dragon Corridor
- Grand Canyon NP Airport
- Narrowwater Rapids
- Little Colorado Confluence
- Desert View FFZ
- Zuni Point Corridor
- Marble Canyon Airport
- Lake Powell
- Page Airport

Scale: 0 5 15 30 Kilometers

See Table 2.1 Characteristics of Air Tour Routes for route designations.

In order to comply with the requirements of MAP-21, the FAA and NPS have provided three incentives:

- ² Substantial restoration of the natural quiet and experience of the park is considered to be achieved in the park if, for at least 75% of each day, 50% of the park is free of noise produced by commercial air tour operations that have an allocation to conduct commercial air tours in the park.

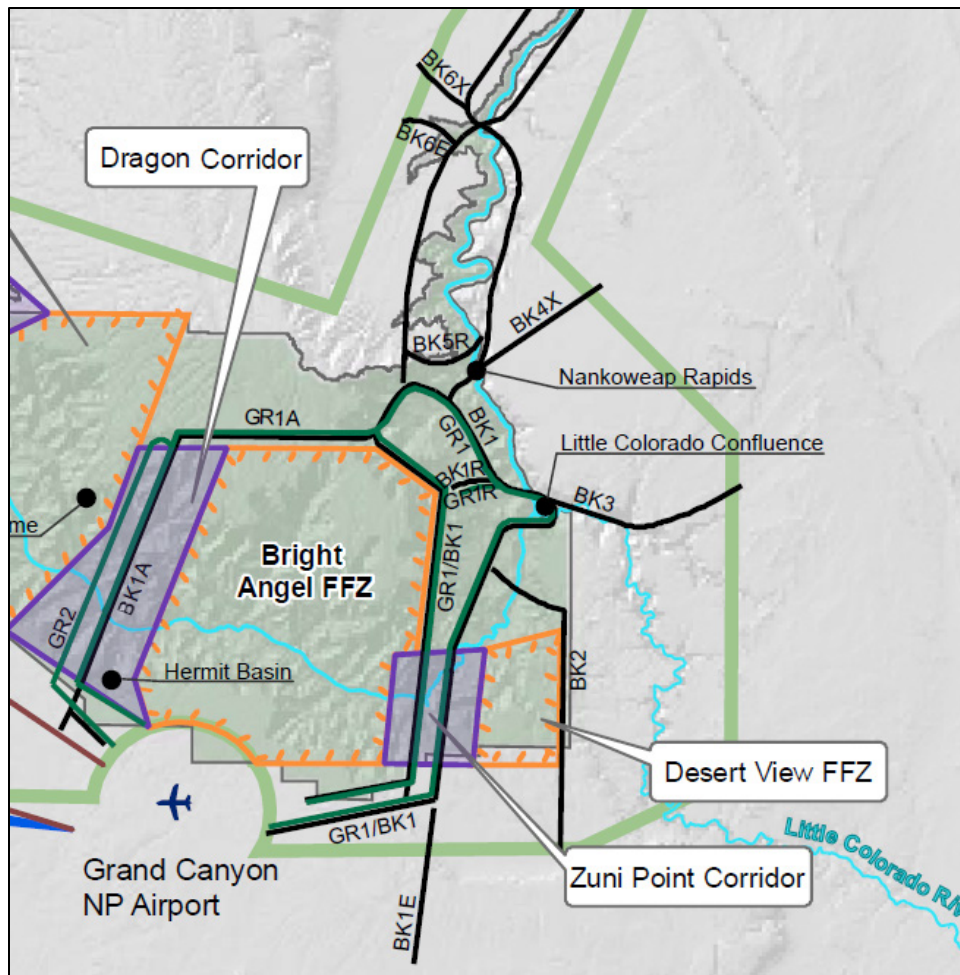


Figure 3. Map detail showing the Dragon and Zuni Point corridors and air tour routes.

Since the cumulative impact of providing QT incentives must a) not increase noise at Grand Canyon and b) not diminish achievement of SRNQ), the NPS and FAA have agreed to analyze each year's commercial air tours flown in the Dragon and Zuni Point corridors through noise modeling. Each year's cumulative air tour noise is assessed and compared to a 2012 baseline (defined in Section 2) to determine if QT use has increased noise—if not, the seasonal incentive for QT use will be continued. The duration of audibility is assessed and compared to the SRNQ definition to ensure that this achievement has not been diminished. It is important to note the cumulative noise assessment described in this report is a basis for judging changes to the noise environment and is not intended to represent actual noise levels which may be experienced by visitors to the park on any particular day. The duration of audibility is assessed and compared to the SRNQ definition to ensure that this achievement has not been diminished. This assessment includes all reported commercial air tours by route. Neither assessment includes exempted flights to and from Hualapai Indian Reservation within the SFRA. The following sections summarize the noise modeling process, the results and yearly assessment, as well as snapshots of the annual reporting data for 2015–2018.

2. Method to Model and Evaluate Noise

The NPS and FAA have developed the following procedure for noise modeling to ensure compliance with the statutory mandate that the cumulative noise produced by all air tour flights in the Dragon and Zuni Point corridors does not exceed a level based on air tours flown in 2012 (79 Federal Register 66763-66765, 80 Federal Register 22606-22611). This methodology utilizes annual reported air tour activity data (number of operations by aircraft type and route) provided by operators as required by 14 C.F.R. Part 93.325—quarterly reporting, as well as the number of operations allocated to operators in the Dragon and Zuni Point corridors per 14 Code of Federal Regulations Part 93.319, Commercial air tour limitations.

2.1 Noise Modeling

The FAA's Integrated Noise Model (INM³) Version 6.2a was used to quantify the amount of noise produced by air tour operations. As creating and executing an INM study is a time-intensive process, INM simulations of each day and every possible air tour operational scenario would be prohibitive. Accordingly, the NPS, FAA, and Volpe Center have agreed to create a series of model scenarios, each of which reflects a single aircraft on a single route for each potential aircraft/route combination flying over Grand Canyon National Park. The model results are in the form of a multidimensional array of $L_{Aeq,12h}$ and time audible for each aircraft/route combination on a regular grid of 1,224 locations with 2 km spacing throughout the park. These grid results are then used as inputs to a script (the NPS Interactive Mapping Tool, or IMT, currently written in R) which can quickly aggregate and analyze the data for numerous user-defined scenarios.

2.1.1 Inputs required

As the raw model data is individual flight-route results, the IMT script⁴ uses a basic CSV file as the scenario input. Each row corresponds to a flight-route run, and each column represents a scenario. Each cell then contains the number of aircraft operations for that flight-route combination for that scenario.

2.1.2 Output Files

For each scenario, a grid file is produced containing the cumulative noise energy and time audible from all operations at each location point, along with maps displaying time audible and sound exposure level⁵ values.

2.2 Aggregate Noise Exposure for QT Incentives Evaluation

In the first part of the evaluation, each year's cumulative air tour noise for operations in the Dragon and Zuni Point corridors is assessed and compared to a 2012 baseline to determine if QT use has increased noise—if not, the seasonal incentive for QT use will be continued.

³ As of May 2015, the Aviation Environmental Design Tool (AEDT) has replaced INM.

⁴ Copies of the script will be provided upon request.

⁵ Sound exposure level is equivalent to the $L_{Aeq,12h}$ compressed into a single second.

2.2.1 Defining Scenarios

For the 2012 baseline year, cumulative noise exposure has been computed for two operational scenarios of interest:

1. **Reported:** number of tour operations reported in the Dragon and Zuni Point corridors in 2012, 40,972, and
2. **Allocated:** number of tour operations allocated in the Dragon and Zuni Point corridors in 2012, 44,911.

Cumulative noise under the allocated scenario is assumed to be a reasonable upper limit for noise, as it is based on the total number of allocated air tours, which is the maximum number of commercial air tours that could have been flown in 2012. Both calculations assume the same proportions of route traffic and aircraft types as in the Dragon and Zuni Point corridors in 2012. Refer to ‘Yearly Reporting Data’ for a description of the process used to organize the reporting data.

The analysis of the 2015 through 2018 air tour reporting data has been conducted with a procedure identical to that used to generate the 2012 reported value.

2.2.2 Cumulative noise exposure computation

For QT incentives evaluation, the cumulative noise exposure has been defined as the total sound energy for the year, averaged over a 12-hour period, and arithmetically averaged over the grid of 1,224 points, resulting in a daytime (7 a.m. to 7 p.m.) A-weighted, time-averaged noise measure ($L_{Aeq,12hr}$). This cumulative noise measure is a geospatial- and time-averaged measure of a specific subset of yearly overflights. The measure should not be construed as a prediction of the level of air tour noise a visitor would experience at any specific location or time within the park.

When computed based on the 2012 allocated scenario, this noise measure is considered by the FAA and NPS as the baseline to ensure compliance with the statutory mandate that the cumulative noise produced by all air tour flights in the Dragon and Zuni Point corridors does not exceed a level based on air tours flown in 2012 (79 FR 66763-66765).

Calculation Methods

$L_{Aeq,12h}$ is a straightforward metric to calculate, as it is an energy average that does not depend on the timing of the aircraft overflights. Every grid in the model is comprised of the INM computed 12-hour average sound levels for each flight-route combination. These values are first converted back to a non-logarithmic value, multiplied by the number of operations, and summed with all other flight-routes for that grid. The formula for this calculation is given below, where x is an array of $L_{Aeq,12h}$ values for all single flight-routes for a particular grid, $nOps$ is an array of the number of operations for all the corresponding flight-routes used in x , and y is the final output value.

$$y = 10 * \log_{10} \left(\sum 10^{\frac{x}{10}} * nOps \right)$$

2.3 Duration of audibility for SRNQ Evaluation

In the second part of the evaluation, to evaluate substantial restoration of natural quiet, an air tour time audible is computed at each of the 1,224 grid points for each day of the year for each type of aircraft on each commercial air tour route reported throughout the entire park (not limited to the Dragon and Zuni Point corridors), based on information contained in the air tour reporting data. The percentage time audible for each day (based on a 12-hour period) at each location was then computed from the summed duration of audibility for all flights on a given day at each location. Because noise from successive or simultaneous flights can overlap in time, this simple summation may overestimate the duration of noise audibility as it would be experienced on the ground. A statistical time compression algorithm (Boeker 2007), which assumes the waiting time between successive flights has a negative exponential distribution, was used to account for this overlap. As the number of flights increases, the gap between air tour noise events decreases. In the extreme case, when there are no moments free from air tour noise, the corrected percent time audible is 100.

Since these data are calculated for every one of the 1,224 grid points in the park, determining whether the park area condition of SRNQ was achieved under a given scenario is simply a matter of dividing the number of points that exceed the threshold by the total number of points in the park. This was calculated for every calendar day, and the results plotted, see section 3.2.

3. Results

3.1 Aggregate Noise Exposure

Table 1 summarizes the aggregate noise exposure results and annual scenario statistics for 2012 and 2015–2018. During these years the cumulative noise produced by all air tour flights in the Dragon and Zuni Point corridors has not exceeded the level based on air tours flown in 2012 (58.1 decibels (dB)). However, cumulative noise has approached the baseline in years where the aircraft activity has approached or exceed the 2012 allocation baseline.⁶ The NPS and FAA will continue modeling noise exposure in the Dragon and Zuni Point corridors annually and based on modeling results, will re-evaluate seasonal relief incentives. Illustration of the yearly energy-averaged noise level for operations in the Dragon and Zuni Point corridors can be found in Figures 4 through 7.

Table 1. Comparison of 2012 allocated, 2012 reported and 2015–2018 annual reported commercial air tour operations in the Dragon and Zuni Point corridors.

Year	Scenario	Dragon Zuni Operations	Percent of Operations of Quiet Technology Aircraft	Energy-Averaged Noise, $L_{Aeq,12hr}$ (dB)
2012	Allocated (Baseline)	44,911	57.8%	58.1
2012	Reported Operations	40,971	57.8%	57.7
2015	Reported Operations	43,731	59.5%	57.8
2016	Reported Operations	44,143	59.1%	57.8
2017	Reported Operations	45,155	59.6%	58.0
2018	Reported Operations	40,086	60.3%	57.4

⁶ Operations may exceed allocations as QT air tours do not need to use an allocation during the first quarter,

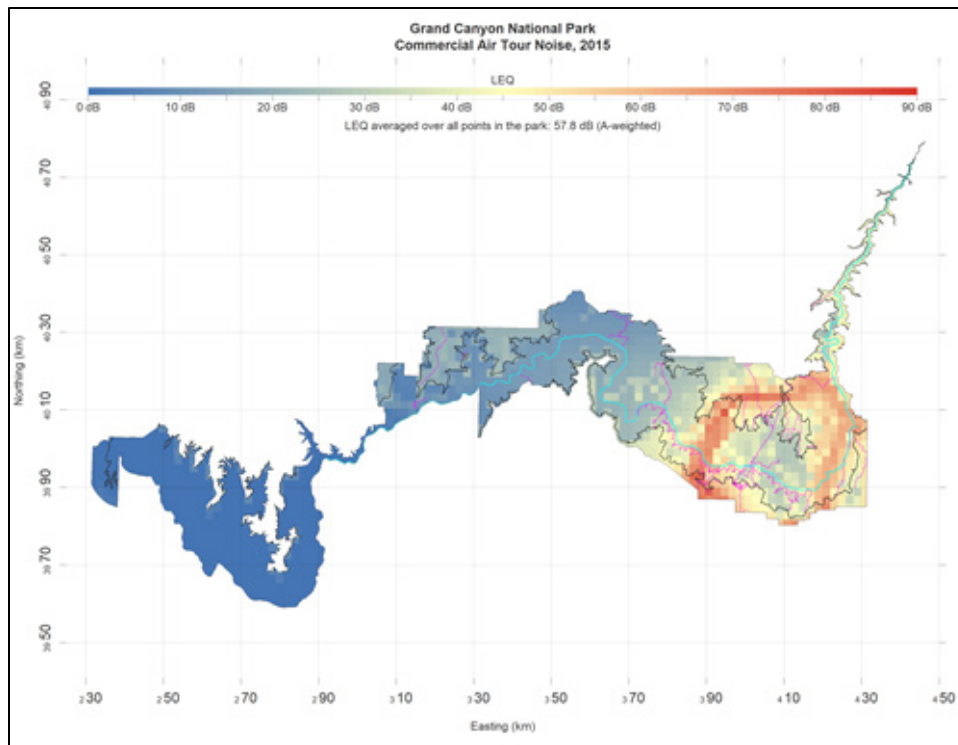


Figure 4. Yearly energy-averaged noise level, $L_{Aeq,12hr}$ (dB), for operations in the Dragon and Zuni Point corridors, 2015.

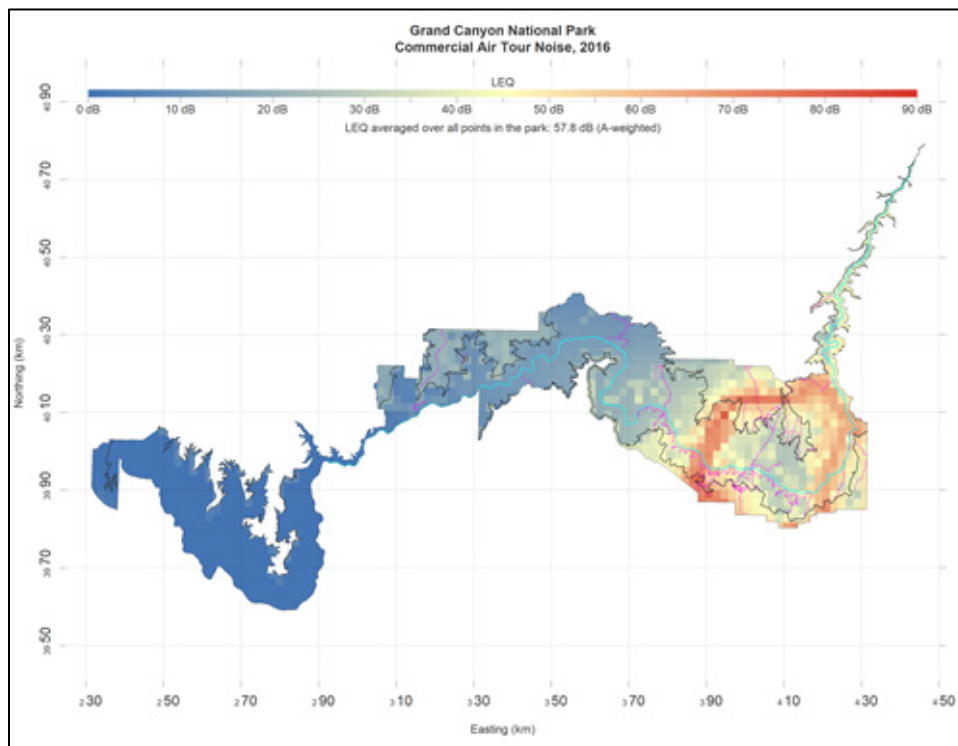


Figure 5. Yearly energy-averaged noise level, $L_{Aeq,12hr}$ (dB), for operations in the Dragon and Zuni Point corridors, 2016.

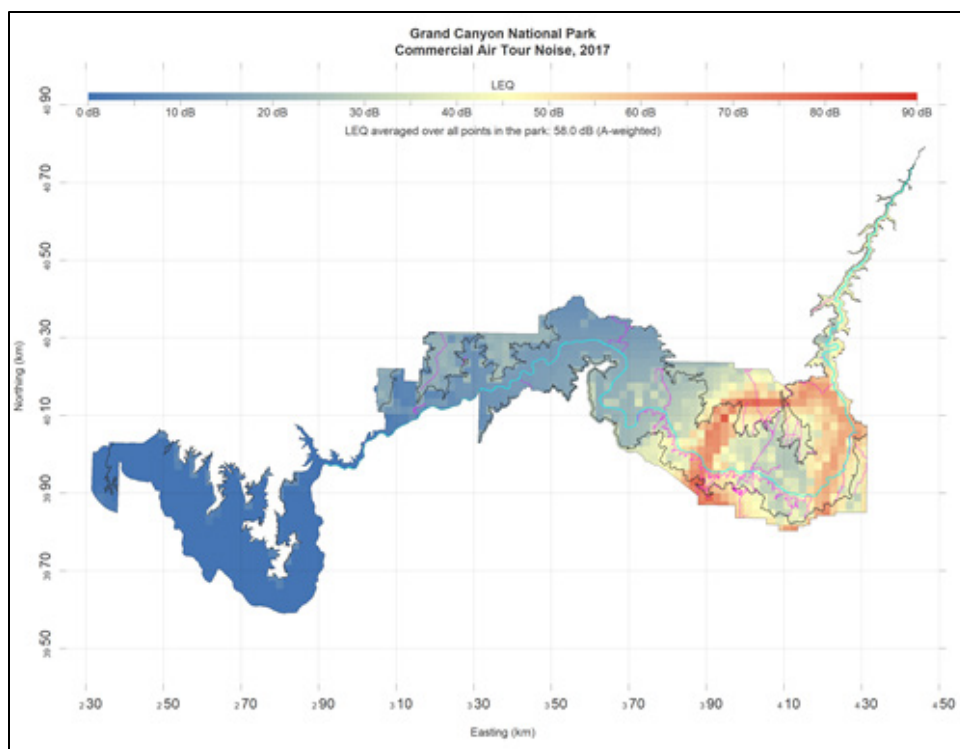


Figure 6. Yearly energy-averaged noise level, $L_{Aeq,12hr}$ (dB), for operations in the Dragon and Zuni Point corridors, 2017.

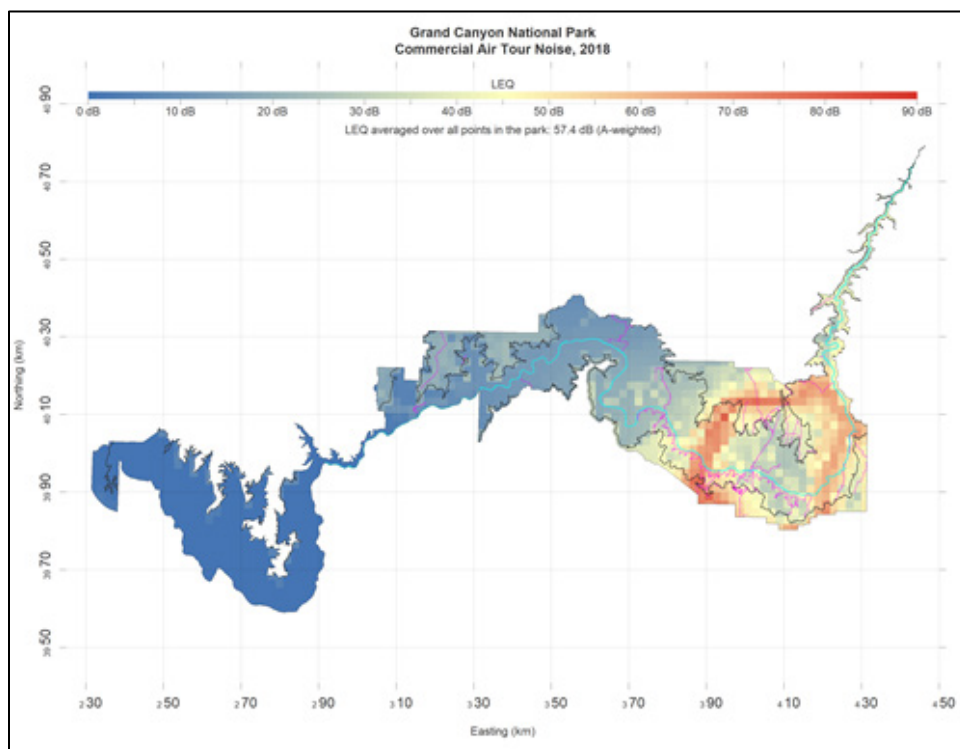


Figure 7. Yearly energy-averaged noise level, $L_{Aeq,12hr}$ (dB), for operations in the Dragon and Zuni Point corridors, 2018.

3.2 Duration of Audibility

Table 2 summarizes the yearly day during which the percentage of the park free of noise for 75% of the day is at a minimum, or conversely, air tour noise is audible for more than 25% of the day. This typically corresponds to a day when operations are at or near peak activity. Substantial restoration of natural quiet is achieved if, during each year, the area of the park free of noise for 75% of the day is not less than 50%.

Table 2. Air tour noise audibility compared to SRNQ threshold for the years 2015–2018.

Year	Date	Daily Operations	Percentage of park where air tour noise was audible more than 25% of day	Percentage of park free of noise for 75% or more of a day	SRNQ achieved?
2015	09-16-2015	287	34.6%	65.4%	Yes
2016	08-11-2016	334	38.3%	61.7%	Yes
2017	08-10-2017	368	35.4%	64.6%	Yes
2018	08-23-2018	256	33.4%	66.6%	Yes

Figures 8–15 illustrate the distribution of the percentage of the park area that experienced time audible greater than 25% of the day. Plot points are grouped either by day or by week, as indicated in the plot title. In each instance, the plots show the area of the park that exceeds the 25% threshold, either daily, or the maximum value exceeded on a daily basis for each week. In each instance, the color scale corresponds to increasing percentages of total park area (1902 square miles), ranging from purple (low) to yellow (high). The greatest percent of park area free from noise more than 70% of the day occurs during the winter months of November–February, except for holiday periods. The smallest percent of park area free from noise typically occurs during the summer months of July–September.

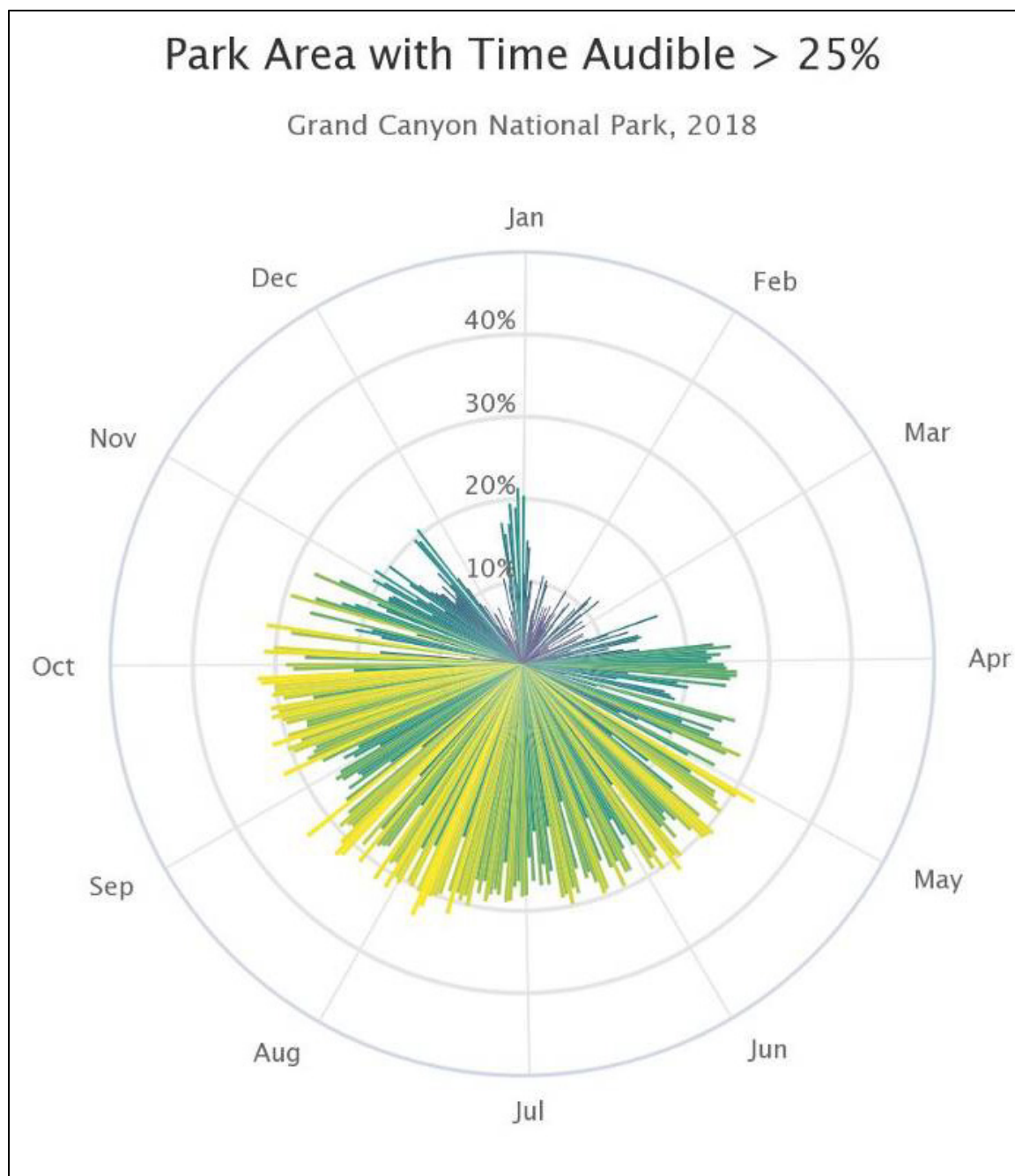


Figure 8. Percent area of Grand Canyon where time audible is greater than 25%, daily values for 2018.

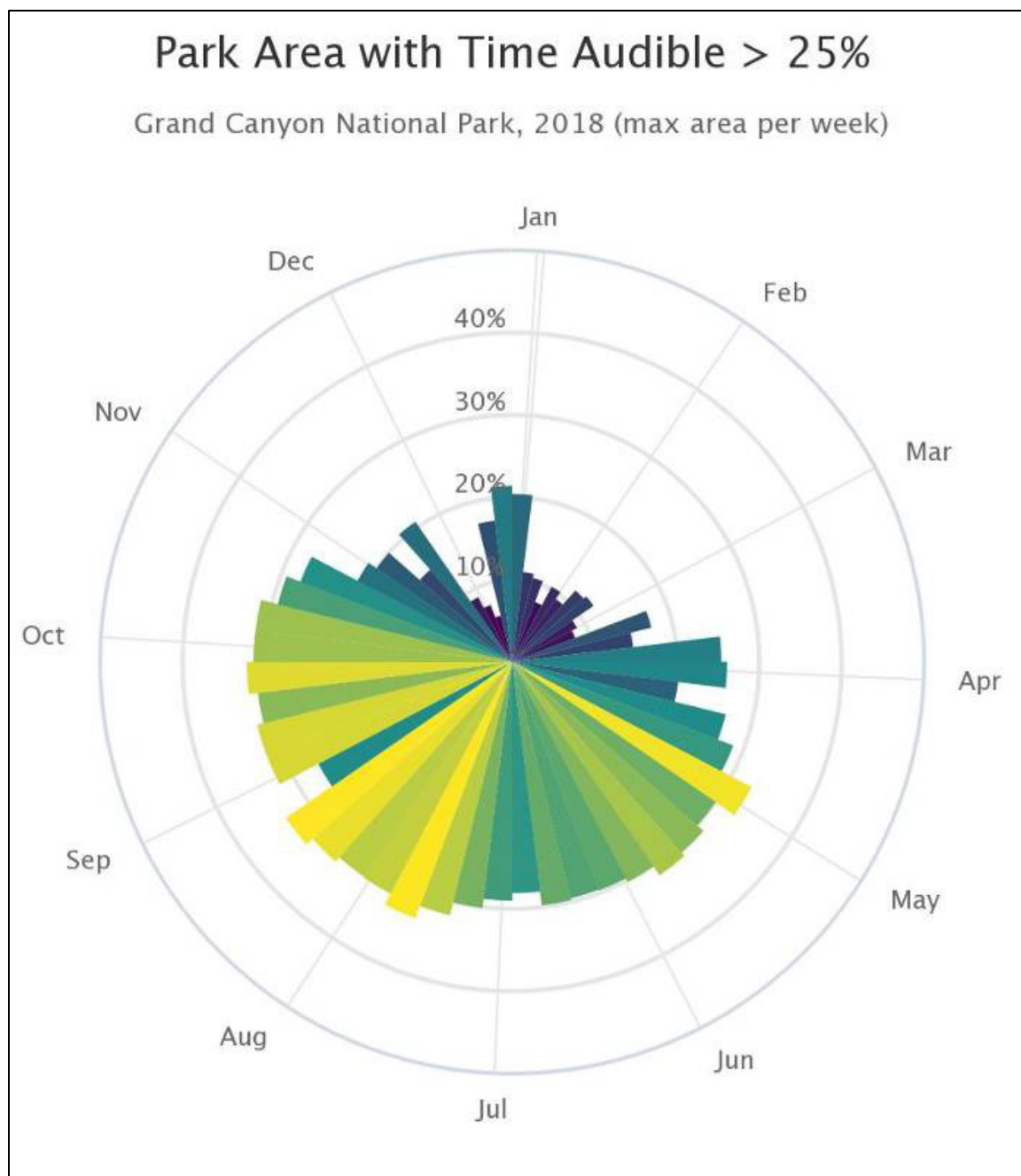


Figure 9. Percent area of Grand Canyon where time audible is greater than 25%, weekly values for 2018.

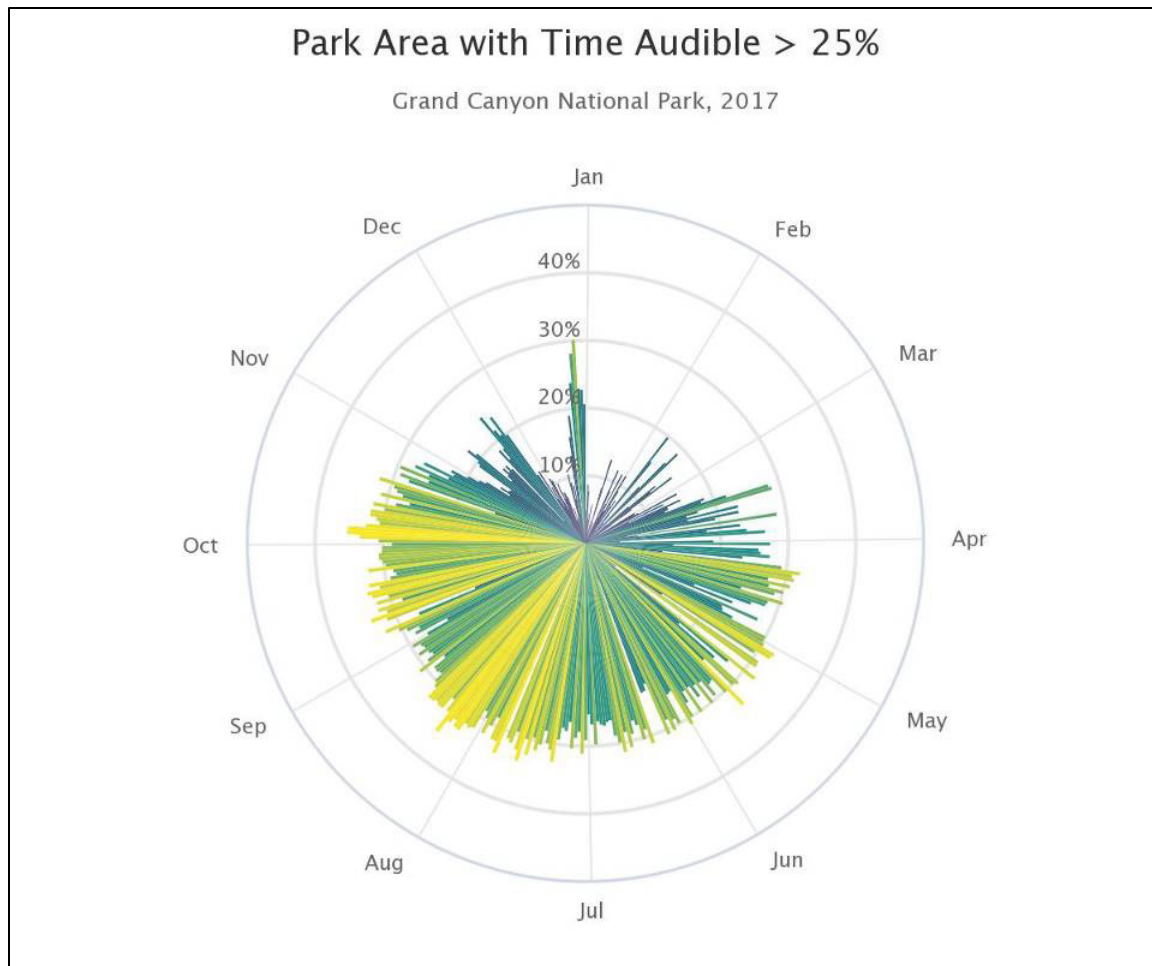


Figure 10. Percent area of Grand Canyon where time audible is greater than 25%, daily values for 2017.

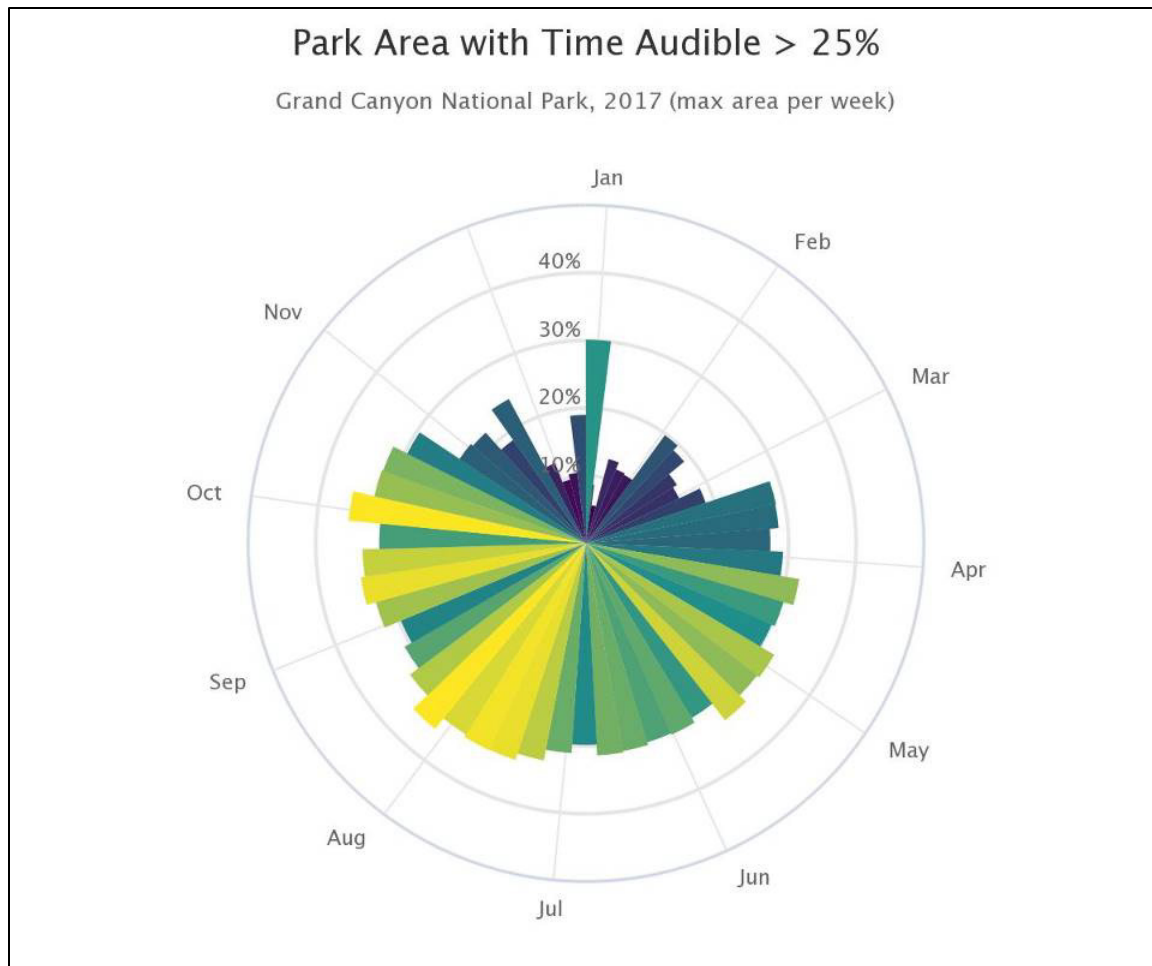


Figure 11. Percent area of Grand Canyon where time audible is greater than 25%, weekly values for 2017.

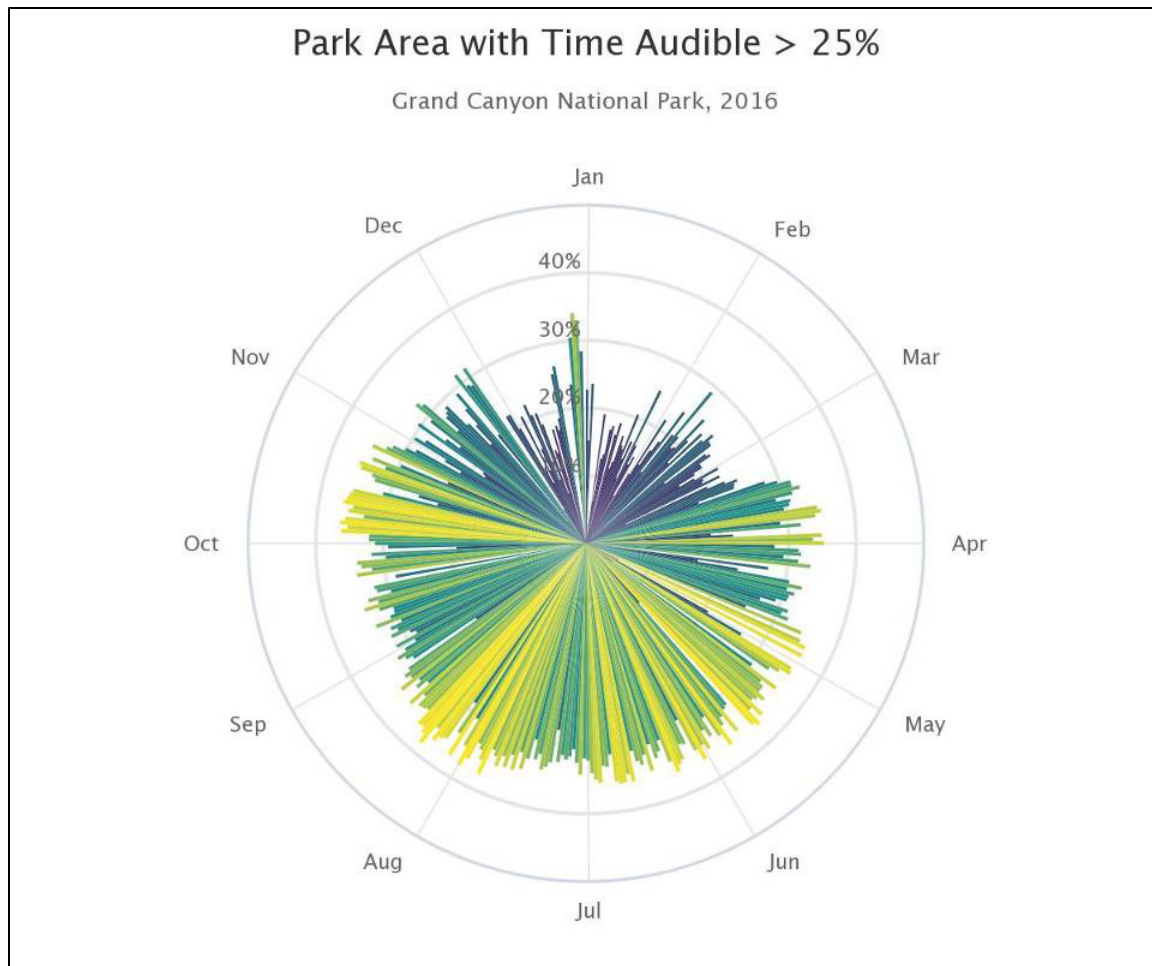


Figure 12. Percent area of Grand Canyon where time audible is greater than 25%, daily values for 2016.

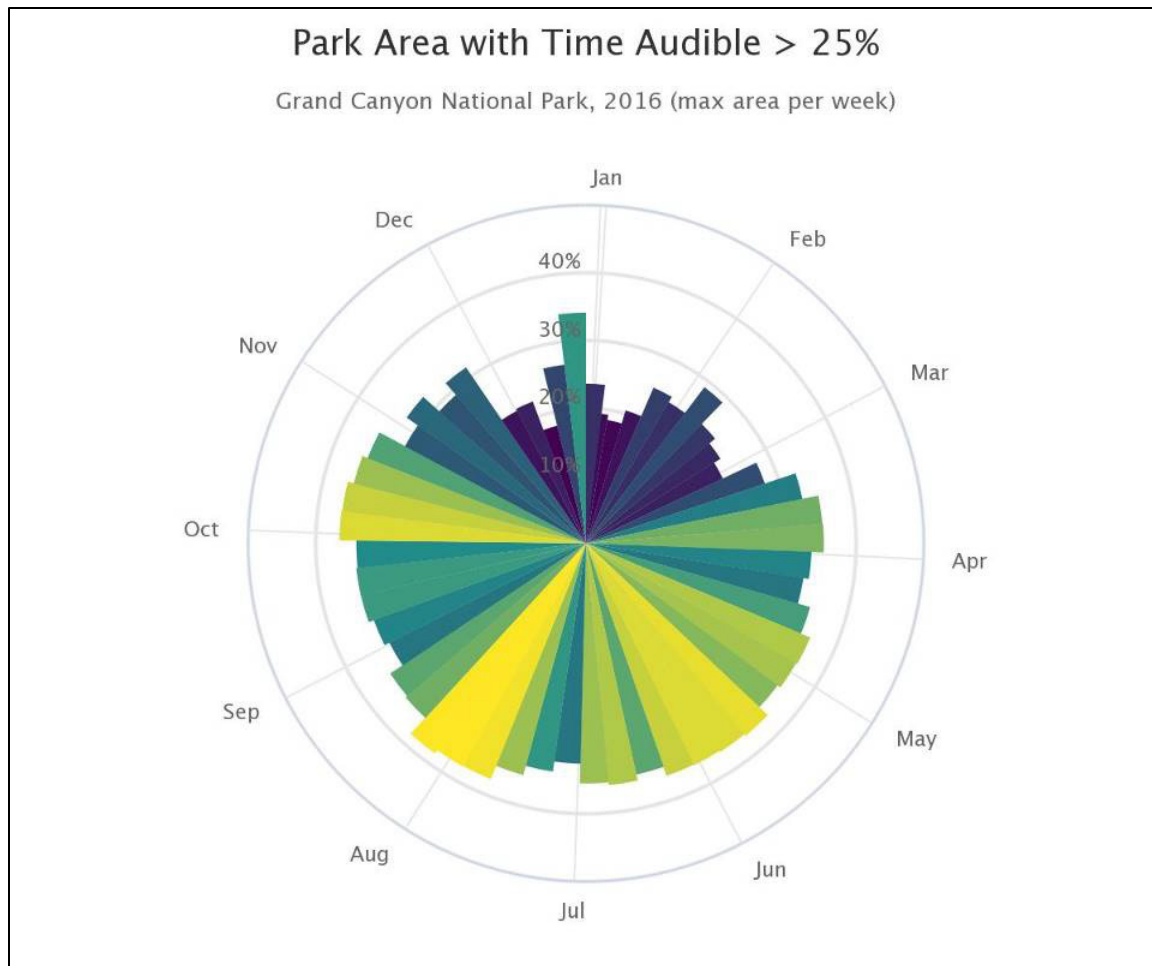


Figure 13. Percent area of Grand Canyon where time audible is greater than 25%, weekly values for 2016.

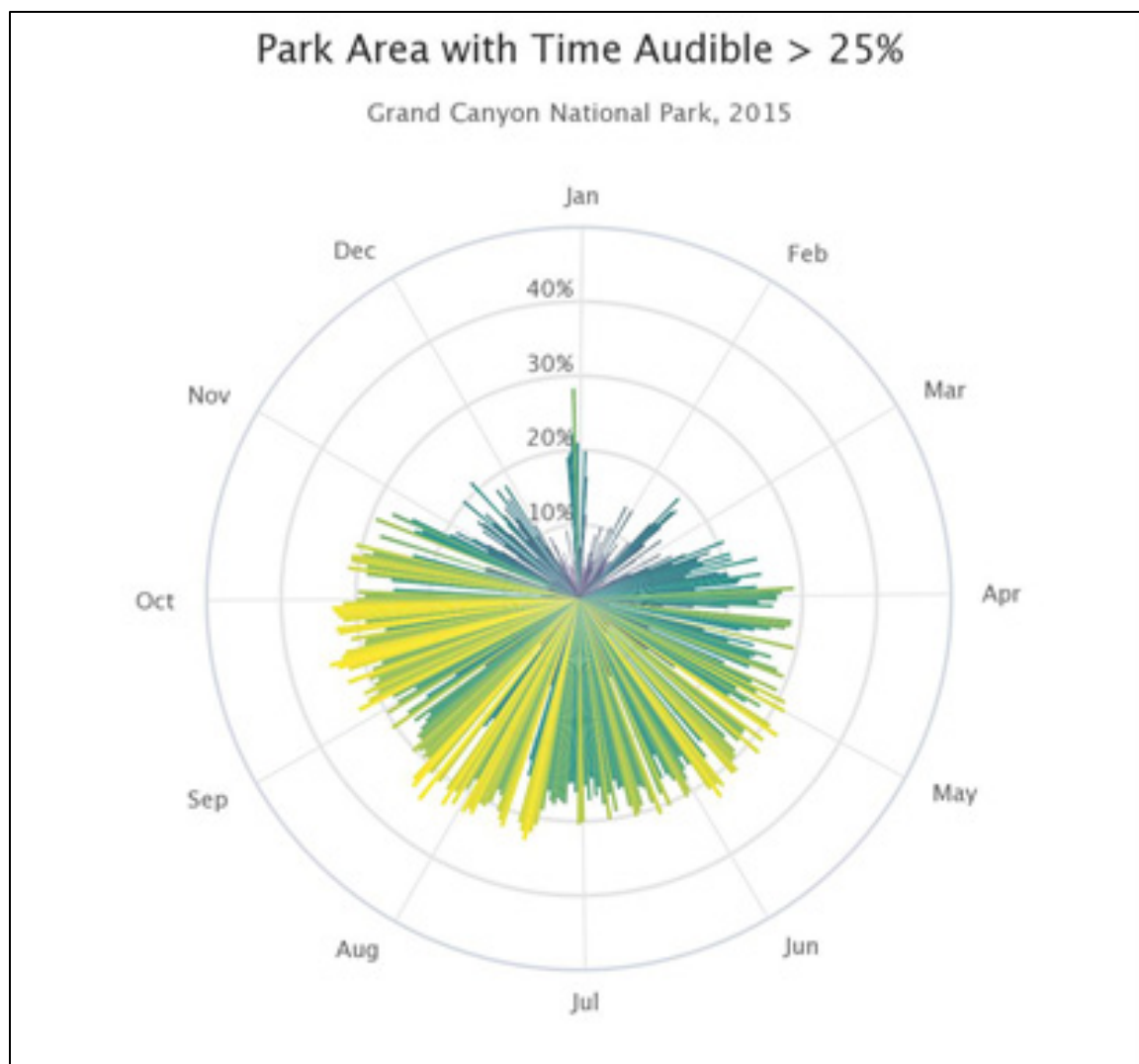


Figure 14. Percent area of Grand Canyon where time audible is greater than 25%, daily values for 2015.

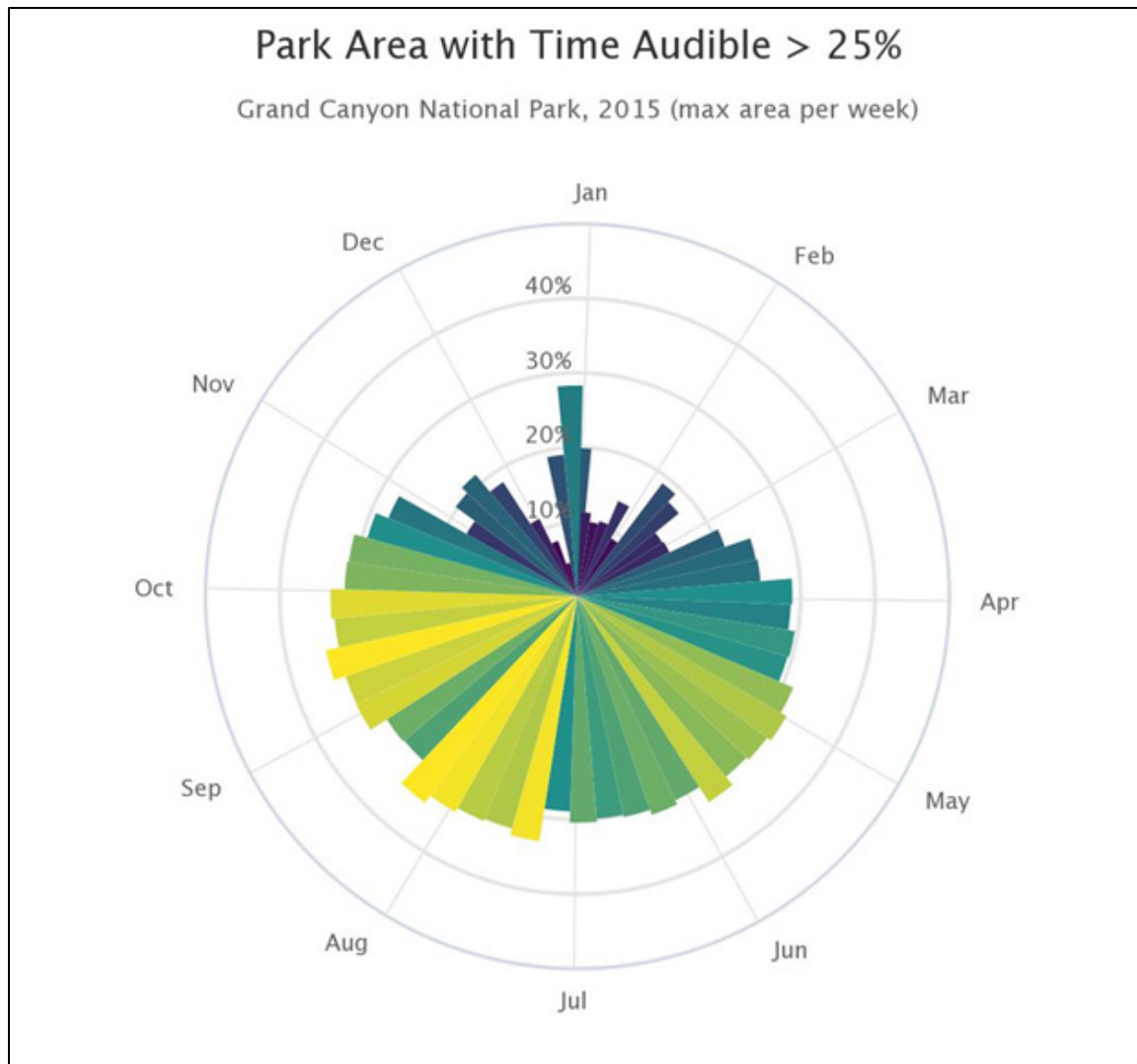


Figure 15. Percent area of Grand Canyon where time audible is greater than 25%, weekly values for 2015.

4. Reporting Data Summary

Table 3 displays a snapshot of quarterly air tours reported for 2015–2018. Table 4 through Table 7 provide quarterly usage tables from 2015–2018 for the Dragon and Zuni Point corridors, including QT usage. Figure 16 provides a graphical summary of these tables, showing the percentage of Dragon and Zuni Point corridors flights using QT by quarter for the years 2015–2018. It is observed that QT usage is greatest in the first quarter, averaging 86%, and dropping in the second through fourth quarters. Quiet technology usage is lowest in the third quarter when total flights are greatest.

Table 3. Reporting data by quarter (Q) for the Dragon and Zuni Point corridors for the years 2015–2018.

Year	January–March (Q1)	April–June (Q2)	July–September (Q3)	October– December (Q4)	Total Air Tours
2015	4,790	13,107	19,488	6,346	43,731
2016	5,336	12,858	18,602	7,347	44,143
2017	4,275	13,427	19,258	8,195	45,155
2018	4,426	11,977	17,808	5,875	40,086

Table 4. Quarterly QT flights for the Dragon and Zuni Point corridors in 2015.

Period	Number of QT Flights, All Aircraft	QT Percentage, All Aircraft	Number of QT Flights, Fixed- Wing	QT Percentage, Fixed Wing	Number of QT Flights, Helicopter	QT Percentage, Helicopter
Q1	3,945	82.4	1,078	91.0	2,867	79.5
Q2	7,745	59.1	2,159	90.7	5,586	52.1
Q3	10,287	52.7	2,153	87.3	8,134	47.8
Q4	4,049	63.8	1,319	91.2	2,730	55.7
Full Year	26,026	59.5	6,709	89.7	19,317	53.3

Table 5. Quarterly QT flights for the Dragon and Zuni Point corridors in 2016.

Period	Number of QT Flights, All Aircraft	QT Percentage, All Aircraft	Number of QT Flights, Fixed-Wing	QT Percentage, Fixed Wing	Number of QT Flights, Helicopter	QT Percentage, Helicopter
Q1	4,508	84.5	1,254	94.7	3,254	81.1
Q2	7,311	56.9	2,015	91.3	5,296	49.7
Q3	9,744	52.4	1,981	89.2	7,763	47.4
Q4	4,540	61.8	1,344	94.4	3,196	54.0
Full Year	26,103	59.1	6,594	91.9	19,509	52.8

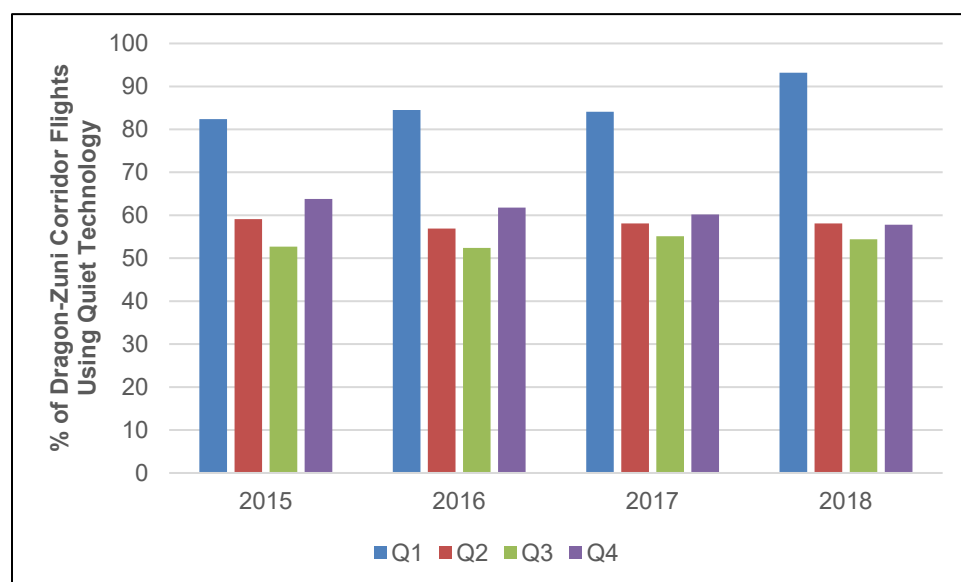


Figure 16. Percentage of flights in the Dragon and Zuni Point corridors using quiet technology by quarter for the years 2015–2018.

Table 6. Quarterly QT flights for the Dragon and Zuni Point corridors in 2017.

Period	Number of QT Flights, All Aircraft	QT Percentage, All Aircraft	Number of QT Flights, Fixed-Wing	QT Percentage, Fixed Wing	Number of QT Flights, Helicopter	QT Percentage, Helicopter
Q1	3,595	84.1	999	94.5	2,596	80.7
Q2	7,802	58.1	2,186	93.0	5,616	50.7
Q3	10,602	55.1	2,114	87.2	8,488	50.4
Q4	4,935	60.2	1,579	88.9	3,356	52.3
Full Year	26,934	59.6	6,878	90.4	20,056	53.4

Table 7. Quarterly QT flights for the Dragon and Zuni Point corridors in 2018.

Period	Number of QT Flights, All Aircraft	QT Percentage, All Aircraft	Number of QT Flights, Fixed- Wing	QT Percentage, Fixed Wing	Number of QT Flights, Helicopter	QT Percentage, Helicopter
Q1	4,123	93.2	969	89.8	3,154	94.2
Q2	6,960	58.1	1,863	86.3	5,097	51.9
Q3	9,683	54.4	2,027	88.3	7,656	49.4
Q4	3,397	57.8	993	87.8	2,404	50.7
Full Year	24,163	60.3	5,852	87.8	18,311	54.8

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NPS 113/181650, June 2022

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