General Aviation Use of the Fossil Canyon Corridor, Grand Canyon National Park

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Introduction

The Fossil Canyon general aviation (GA) corridor is one of two air corridors over the Grand Canyon specifically for use by general aviation aircraft (Figure 1). The Fossil Canyon GA corridor runs southwest to northeast at altitudes of 10,500 or 12,500 ft above mean sea level (MSL) southbound and 11,500 or 13,500 ft MSL northbound. Aircraft using the GA corridor are most likely propeller planes flying at lower altitudes and using visual flight rules (VFR). An acoustic system underneath the Fossil Canyon GA corridor collected sound data and the number of general aviation aircraft using the corridor was determined from these data. Spectrograms of the sound pressure level data allowed sound sources to be visually identified and aircraft counted.

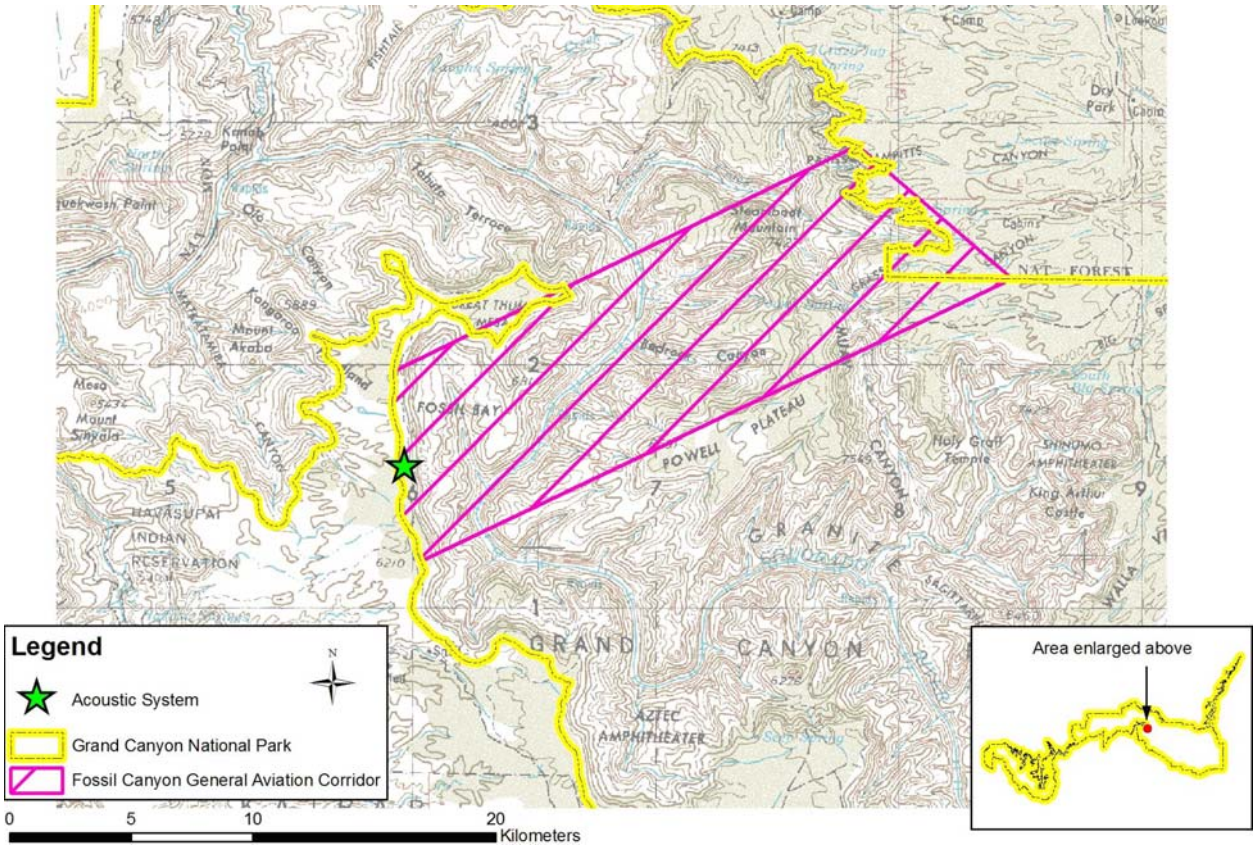

Figure 1.Fossil Canyon GA corridor with acoustic system identified by green star.

Methods

The sound system consisted of a Panasonic CF-18 Toughbook laptop, an ANSI Type 1 Larson-Davis sound level meter (model 824), microphone (GRAS 40AE; protected by a Larson-Davis Environmental Shroud, including a foam windscreen and bird spike) and preamplifier (Larson-Davis 902; Figure 2). This system is known to be accurate within 1 dBA. Two arrays of solar panels were used to recharge the 12-volt batteries which powered the system. An anemometer (Young Model 05103) was also attached to the system to acquire wind speed and direction every second. SoundMonitor software SM060715 (© Far North Aquatics, Fairbanks, AK) compiled all of the data from the various instrumentation.

Figure 2. Sound system under the Fossil Canyon GA corridor consisting of microphone with foam windscreen on tripod on left, two arrays of solar panels, and wind gauge (camouflaged) on tripod on right. Laptop, sound level meter and 12V batteries are in pelican cases underneath solar panels.

Recordings were collected for 10 seconds every two minutes, which is a sufficient sample to capture an aircraft overflight. Recordings of loud events were triggered when the sound pressure level exceeded 50 dBA for 10 seconds or 75 dBA for 1 second. Sound pressure level (SPL) data was collected every second. Observer logging was conducted for at least one hour every month during daytime hours (0700 to 1900).

The time between aircraft events, or noise-free intervals (NFI), and percent time audible of aircraft were determined from observer logging at the site. SPL data were plotted as spectrograms which display frequency (Hz) on the y-axis, time (minutes) on the x-axis, and amplitude (decibels) in color. Sound sources (propeller, airplane, helicopter, jet) were visually identified from spectrograms of the SPL data, and the number of planes using the corridor tallied. A year of acoustic data (11/1/06 to 10/31/07) was analyzed for this project.

Definitions

Audibility: The ability of animals with normal hearing, including humans, to hear a given sound. Audibility is affected by the hearing ability of the animal, other simultaneous interfering sounds or stimuli, and by the frequency content and amplitude of the sound.
Decibel (dB): A logarithmic measure of sound. The decibel provides the possibility of representing a large span of signal levels in a simple manner as opposed to using the basic unit Pascal. The difference between the sound pressure for silence versus a loud sound is a factor of 1,000,000:1 or more, therefore it is less cumbersome to use a small range of equivalent values: 0 to 130 decibels.
A-Weighted Decibel (dBA): A-weighting de-emphasizes the high (6.3 kHz and above) and low (below 1 kHz) frequencies, and emphasizes the frequencies between 1 kHz and 6.3 kHz, in an effort to simulate the relative response of human hearing.

Frequency: The number of times per second that the sine wave of sound repeats itself. It can be expressed in cycles per second, or Hertz (Hz). Frequency equals speed of sound/wavelength.
L_{50}: The sound level, in decibels, exceeded 50% of the measurement period. L_{50} is the same as the median.
L_{max}: The maximum sound pressure level for a given period.
Sound Pressure Level (SPL): The logarithmic form of sound pressure. In air, 20 times the logarithm of the ratio of the actual sound pressure to a reference sound (20 micropascals, the assumed threshold of human hearing).

Results

Observer Logging

Due to the long travel time to get to the site, most logging occurred midday during the 1200 hour. However, when early morning logging sessions did occur, they yielded longer NFIs and lower percent time audible of jets (Appendix A). The longest mean (9.4 minutes) and maximum (26.8 minutes) NFIs occurred in September 2007 and the shortest mean NFI of 0.9 minutes occurred in February 2007 (Figure 3). The average NFI was 2.8 minutes and the average maximum NFI was 11.1 minutes. Jets, propeller planes and helicopters were all heard while logging at the site (Figure 4). Logging did not occur in October 2007 because the site was not visited during that month.

Jets were heard, on average, 28.0% of the time. The highest percent time audible of jets of 45.6% was logged in March 2007. Propeller planes (likely GA aircraft) were heard, on average, 3.8% of the time and helicopters were rarely heard, only 0.3% of the time.

Spectrograms

Propeller planes were identified on the spectrograms by their 'staircase' or 'corkscrew' signature shape and were confirmed by listening to the recordings (Figure 5). High altitude jets had an equally distinct signature on a spectrogram. Other sounds were identified by time of day and frequency content.

March 2007 and June 2007 had the highest numbers of propeller planes in one month and also the highest daily averages for the year (Table 1, Figure 6 and Appendix B). December 2006 had the fewest number of propeller planes using the GA corridor. A total of 1,504 propeller planes used the corridor in 10 months with an average of five planes per day. The microphone on the sound system was damaged on August 26, 2007 by elk and wasn't repaired until September 20, 2007 rendering the data from that period unusable. Because complete data for August and September 2007 were not available, data from those months were removed.

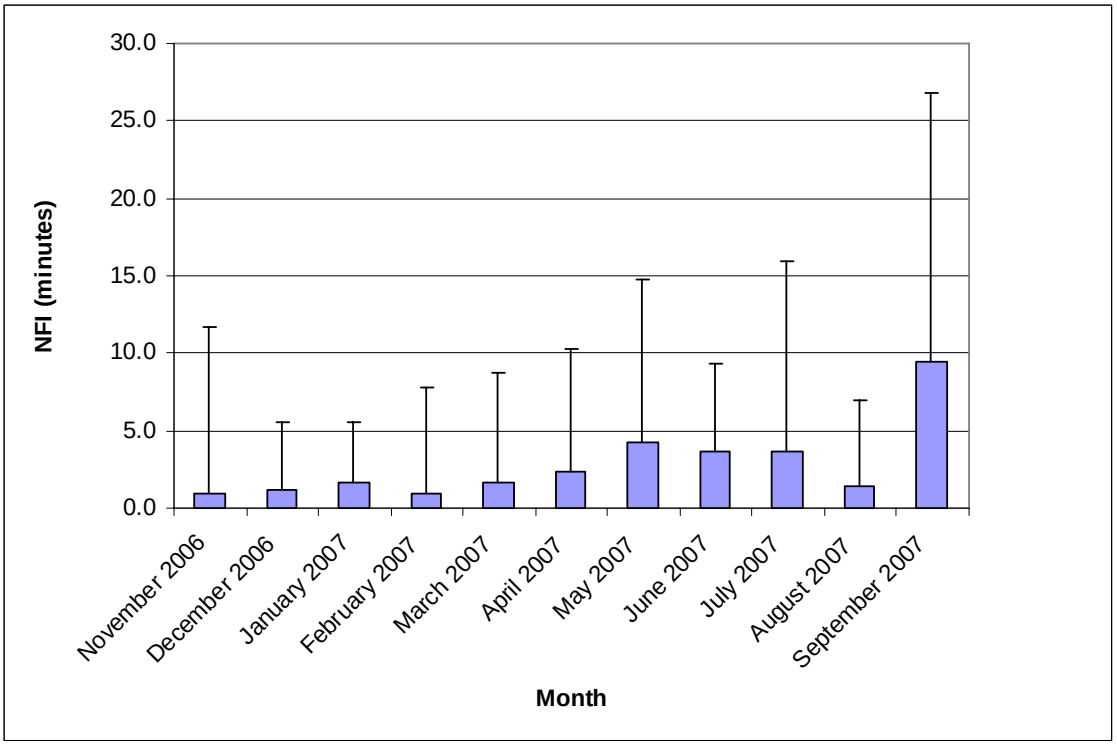

Figure 3. Mean (columns) and maximum (bars) noise free intervals from monthly observer logging sessions, November 2006 to September 2007.

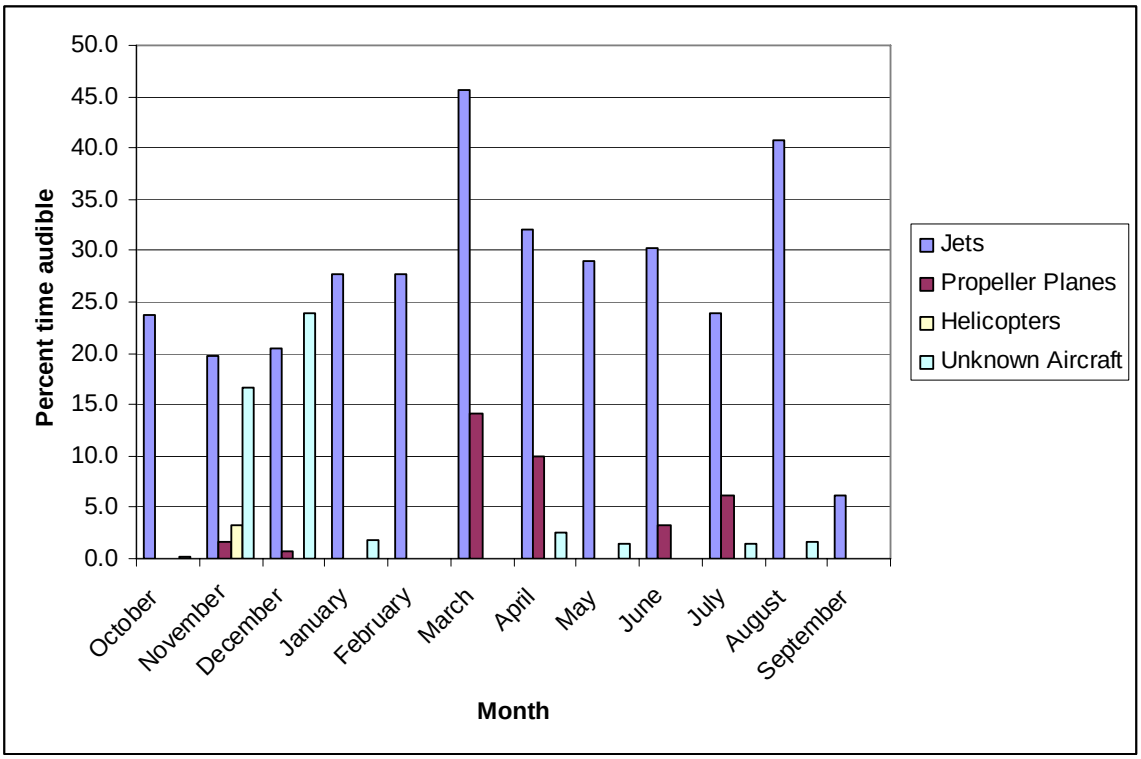

Figure 4. Percent time audible of aircraft during monthly, one hour, observer logging sessions, October 2006 to September 2007.

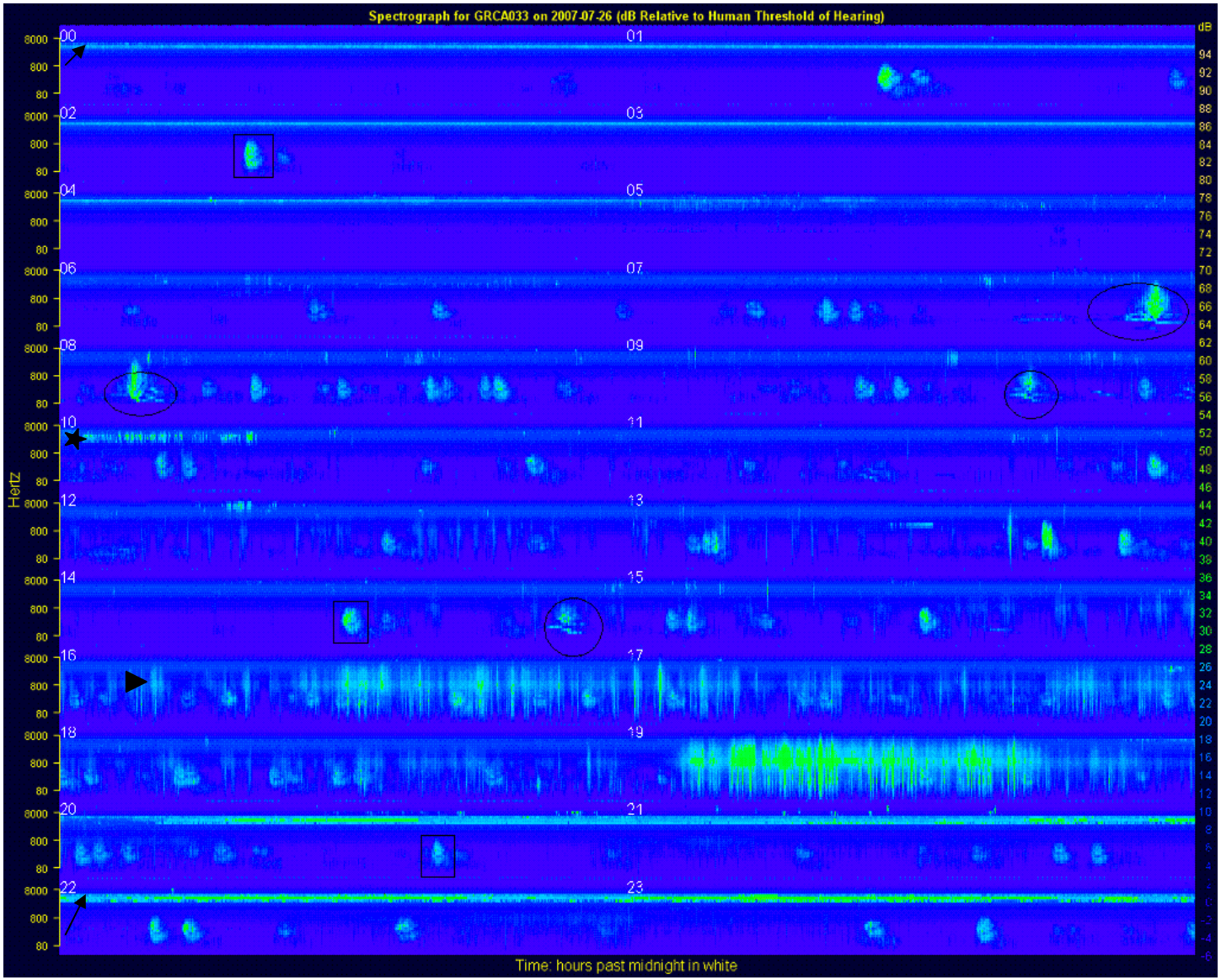

Figure 5. An example of a spectrogram of SPL data used for this study. Data from July 26th, 2007. Propeller planes are circled, some, but not all, jets are marked by rectangles, arrows indicate insects, star illustrates birds, and black triangle points to wind signatures.

Table 1. Monthly totals and daily averages of propeller planes using the Fossil Canyon GA corridor 11/1/06 to 10/31/07.

Month	# of Propeller Planes	Daily Average	Min/Day	Max/Day
November 2006	116	3.9	0	12
December 2006	108	3.5	0	8
January 2007	132	4.3	0	14
February 2007	146	5.2	0	11
March 2007	202	6.7	0	15
April 2007	143	4.8	0	11
May 2007	173	5.6	1	11
June 2007	206	6.9	1	11
July 2007	167	5.4	1	14
October 2007	111	3.6	0	9
TOTAL	1,504	5.0	NA	NA

*Microphone damaged from 8/26/07 to 9/20/07. Therefore, complete data from August and September 2007 are not available.

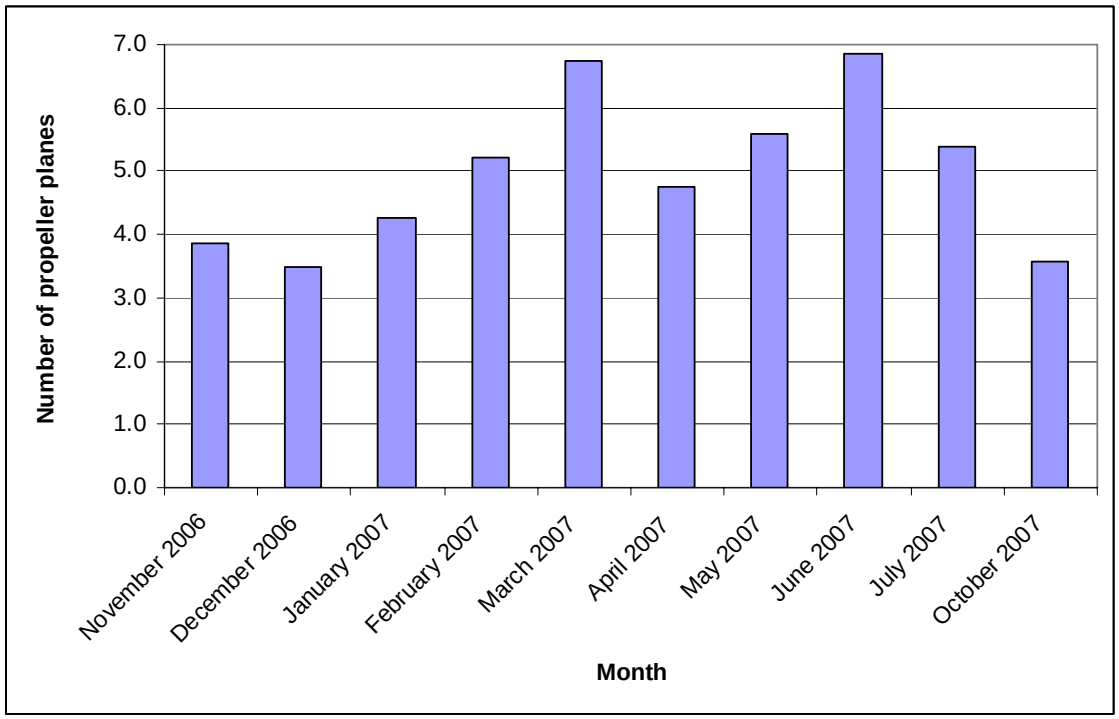

Figure 6. Average daily number of propeller planes (based on monthly totals) using the Fossil Canyon GA corridor November 2006 to October 2007. Full months of data were not collected from August and September 2007, therefore the data from those months were not used.

Sound Pressure Levels

The sound levels at the acoustic monitoring site were low (Table 2). The median sound level (L_{50}) during daytime hours (0700-1900) was 20.1 dBA, just above the noise floor of the instruments (15 dBA). Nighttime (1900-0700) median sound levels are slightly lower at 18.7

dBA. The maximum sound levels at this site (92.0 – 93.9 dBA) are related to loud thunder events during the summer months.

Table 2. Daytime, nighttime and 24 hour sound pressure levels (dBA) 11/1/06 to 10/31/07.

Hours	L_{50}	L_{max}	# of hours analyzed
0700-1900	20.1	93.9	4,051
1900-0700	18.7	92.0	4,080
0000-2400	19.6	93.9	8,131

Discussion

Propeller plane use of the Fossil Canyon GA corridor is relatively low throughout the year, ranging from zero to fifteen propeller flights per day, with an average of five. The monthly observer logging revealed that jets have the highest percent time audible of all aircraft types; propeller planes had the second highest percent time audible and helicopters had the least, only heard during a logging session in November 2006. The spectrograms created from the SPL data confirmed these results. Although the number of jets was not counted, they are by far the most common aircraft seen on the spectrograms. Only a few helicopters were seen on the spectrograms. Helicopters that were heard at the site were most likely either the NPS helicopter or a helicopter traveling to the nearby Havasupai village.

Although at least 1500 propeller aircraft used the Fossil Canyon GA corridor in ten months (November 1st 2006 to July 31st 2007 and October 1st to October 31st 2007), sound pressure levels at the acoustic site are relatively low. Daytime median sound levels under the Fossil Canyon GA corridor are equivalent to the natural ambient sound levels in Pinyon-Juniper woodlands in Grand Canyon National Park of 20.0 dBA (Levy and Falzarano, 2007). Sound levels are also within 5 dBA of the noise floor of the instrument, indicating that a low noise microphone should be used for future data collection at this site.

References

Levy, Laura and Sarah Falzarano, 2007. Summer Replicate Ambient Sound Levels, Grand Canyon National Park. NPS Report No. GRCA-07-06.

Acknowledgements

Thanks to Mark Wunner, KJ Glover, Ellen Brennan, Chris Flaccus, Emma Benenati, Michael Schramm, Skip Ambrose, Chris Florian, Lon Ayers, Dana Erickson, Cecelia Overby and Grant Copper for assistance with field work. Data was analyzed using programs created by Ric Hupalo and Damon Joyce of the NPS Natural Sounds Program.

Appendix A

Percent time audible and noise free interval from observer logging sessions. LL = Laura Levy, SF = Sarah Falzarano.

Sound Source	11/16/06 10:00 LL	12/13/06 12:00 LL	1/17/07 12:00 LL	2/15/07 13:00 LL	3/21/07 12:00 LL	4/23/07 12:00 LL	4/23/07 12:00 SF	5/14/07 12:00 LL	6/15/07 12:00 LL	7/10/07 12:00 LL	8/15/07 11:00 LL	9/20/07 12:30 LL
No Sound Audible	13.9	26.4	6.7	1.9	0.0	1.1	2.8	0.0	0.0	0.0	0.0	0.0
Aircraft, unknown	16.7	23.9	1.9	0.0	0.0	5.0	0.0	1.4	0.0	1.4	1.7	0.0
Jet Aircraft	19.7	20.6	27.8	27.8	45.6	32.5	31.7	28.9	30.3	23.9	40.8	6.1
Propeller Aircraft	1.7	0.8	0.0	0.0	14.2	7.2	12.5	0.0	0.0	0.0	0.0	0.0
Helicopter	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Motor Sounds	0.0	0.0	7.2	20.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Wind	44.7	8.1	76.4	79.4	81.9	63.6	66.1	52.8	23.6	35.0	18.9	96.9
Water	0.0	0.0	0.0	0.0	0.0	7.2	3.1	0.0	0.0	0.0	0.0	0.0
Thunder	0.0	0.0	0.0	0.0	0.0	1.1	1.1	0.3	0.0	0.0	0.0	0.0
Bird	13.3	40.6	11.7	16.4	25.0	81.7	50.8	95.3	82.8	92.5	60.3	24.2
Insect	14.7	8.9	0.0	12.2	10.8	12.2	10.6	46.1	53.1	53.9	64.7	20.3
Animal, unknown	0.6	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0
Mean NFI	1.0	1.2	1.6	0.9	1.7	1.7	3.0	4.2	3.7	3.7	1.4	9.4
Maximum NFl	11.7	5.5	5.5	7.8	8.7	10.3	10.3	14.8	9.3	16.0	7.0	26.8

Appendix B

Number of propeller flights per day, November 1st, 2006 to April 30th, 2007.

Date	# of prop flights	Date	# of prop flights	Date	# of prop flights	Date	# of prop flights	Date	# of prop flights	Date	# of prop flights
11/1/06	4	12/1/06	1	1/1/07	14	2/1/07	7	3/1/07	3	4/1/07	3
11/2/06	7	12/2/06	3	1/2/07	9	2/2/07	11	3/2/07	4	4/2/07	9
11/3/06	7	12/3/06	2	1/3/07	8	2/3/07	2	3/3/07	3	4/3/07	3
11/4/06	2	12/4/06	2	1/4/07	5	2/4/07	7	3/4/07	3	4/4/07	10
11/5/06	2	12/5/06	4	1/5/07	5	2/5/07	3	3/5/07	11	4/5/07	8
11/6/06	3	12/6/06	3	1/6/07	4	2/6/07	2	3/6/07	5	4/6/07	11
11/7/06	2	12/7/06	5	1/7/07	6	2/7/07	1	3/7/07	8	4/7/07	4
11/8/06	4	12/8/06	5	1/8/07	1	2/8/07	2	3/8/07	9	4/8/07	3
11/9/06	2	12/9/06	6	1/9/07	2	2/9/07	6	3/9/07	15	4/9/07	5
11/10/06	1	12/10/06	4	1/10/07	6	2/10/07	3	3/10/07	7	4/10/07	2
11/11/06	5	12/11/06	2	1/11/07	3	2/11/07	5	3/11/07	14	4/11/07	6
11/12/06	9	12/12/06	0	1/12/07	3	2/12/07	2	3/12/07	7	4/12/07	7
11/13/06	7	12/13/06	3	1/13/07	1	2/13/07	5	3/13/07	3	4/13/07	4
11/14/06	1	12/14/06	3	1/14/07	4	2/14/07	0	3/14/07	15	4/14/07	4
11/15/06	3	12/15/06	3	1/15/07	4	2/15/07	5	3/15/07	10	4/15/07	7
11/16/06	2	12/16/06	6	1/16/07	5	2/16/07	7	3/16/07	2	4/16/07	4
11/17/06	4	12/17/06	1	1/17/07	3	2/17/07	7	3/17/07	9	4/17/07	3
11/18/06	1	12/18/06	1	1/18/07	4	2/18/07	6	3/18/07	15	4/18/07	0
11/19/06	6	12/19/06	3	1/19/07	3	2/19/07	8	3/19/07	8	4/19/07	10
11/20/06	1	12/20/06	6	1/20/07	4	2/20/07	9	3/20/07	2	4/20/07	3
11/21/06	4	12/21/06	4	1/21/07	2	2/21/07	11	3/21/07	4	4/21/07	1
11/22/06	6	12/22/06	8	1/22/07	2	2/22/07	8	3/22/07	3	4/22/07	0
11/23/06	1	12/23/06	2	1/23/07	3	2/23/07	9	3/23/07	4	4/23/07	2
11/24/06	7	12/24/06	2	1/24/07	2	2/24/07	4	3/24/07	5	4/24/07	2
11/25/06	1	12/25/06	2	1/25/07	2	2/25/07	7	3/25/07	8	4/25/07	5
11/26/06	12	12/26/06	4	1/26/07	6	2/26/07	3	3/26/07	4	4/26/07	6
11/27/06	4	12/27/06	2	1/27/07	4	2/27/07	0	3/27/07	3	4/27/07	6
11/28/06	4	12/28/06	2	1/28/07	11	2/28/07	6	3/28/07	5	4/28/07	5
11/29/06	4	12/29/06	5	1/29/07	4			3/29/07	0	4/29/07	7
11/30/06	0	12/30/06	6	1/30/07	2			3/30/07	4	4/30/07	3
		12/31/06	8	1/31/07	0			3/31/07	9		
Monthly Total	116		108		132		146		202		143
Daily Average	3.9		3.5		4.3		5.2		6.7		4.8

Number of propeller flights per day, May 1st, 2007 to October 31st, 2007.

Date	# of prop flights	Date	# of prop flights	Date	# of prop flights	Date	# of prop flights	Date	# of prop flights	Date	# of prop flights
5/1/07	6	6/1/07	8	7/1/07	8	8/1/07	5	9/1/07	NA*	10/1/07	3
5/2/07	1	6/2/07	7	7/2/07	1	8/2/07	8	9/2/07	NA*	10/2/07	4
5/3/07	8	6/3/07	7	7/3/07	1	8/3/07	9	9/3/07	NA*	10/3/07	4
5/4/07	4	6/4/07	9	7/4/07	5	8/4/07	7	9/4/07	NA*	10/4/07	0
5/5/07	6	6/5/07	1	7/5/07	4	8/5/07	6	9/5/07	NA*	10/5/07	1
5/6/07	3	6/6/07	1	7/6/07	12	8/6/07	10	9/6/07	NA*	10/6/07	3
5/7/07	2	6/7/07	7	7/7/07	3	8/7/07	11	9/7/07	NA*	10/7/07	5
5/8/07	5	6/8/07	10	7/8/07	6	8/8/07	4	9/8/07	NA*	10/8/07	4
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5/13/07	5	6/13/07	9	7/13/07	8	8/13/07	3	9/13/07	NA*	10/13/07	6
5/14/07	4	6/14/07	10	7/14/07	2	8/14/07	7	9/14/07	NA*	10/14/07	8
5/15/07	11	6/15/07	9	7/15/07	9	8/15/07	6	9/15/07	NA*	10/15/07	2
5/16/07	5	6/16/07	7	7/16/07	7	8/16/07	13	9/16/07	NA*	10/16/07	2
5/17/07	7	6/17/07	6	7/17/07	5	8/17/07	4	9/17/07	NA*	10/17/07	1
5/18/07	3	6/18/07	8	7/18/07	4	8/18/07	6	9/18/07	NA*	10/18/07	5
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5/26/07	4	6/26/07	11	7/26/07	4	8/26/07	4	9/26/07	5	10/26/07	4
5/27/07	6	6/27/07	4	7/27/07	4	8/27/07	NA*	9/27/07	5	10/27/07	9
5/28/07	10	6/28/07	5	7/28/07	2	8/28/07	NA*	9/28/07	2	10/28/07	5
5/29/07	5	6/29/07	4	7/29/07	5	8/29/07	NA*	9/29/07	0	10/29/07	5
5/30/07	7	6/30/07	6	7/30/07	9	8/30/07	NA*	9/30/07	4	10/30/07	2
5/31/07	5			7/31/07	1	8/31/07	NA*			10/31/07	5
Monthly Total	173		206		167		159		41		111
Daily Average	5.6		6.9		5.4		6.1		3.6		3.6

NA* indicates days when no data were collected because the microphone was damaged by wildlife. Monthly totals and averages for August and September 2007 are therefore minimums.