Global Explorers "Leading the Way"

Soundscape Project

Colorado River, Grand Canyon National Park

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in cooperation with

Grand Canyon Youth

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Introduction

The Soundscape Program at Grand Canyon National Park seeks to characterize the acoustic environment in the park. Part of this characterization relies on people to sit at various locations throughout the park, listen to their surroundings, and document the sound sources and durations. This information provides the program with quantitative measures of natural and non-natural sounds, including the types of sounds heard at a location, the percent time audible of those sounds and the noise free interval (NFI).

In July 2008, a group of visually-impaired and sighted high school students embarked on a trip down the Colorado River through Grand Canyon National Park. Part of the agenda was to collect data for the Soundscape Program. People with visual impairment may rely more heavily on other senses to provide feedback about their environment. Often, they have a heightened sense of hearing. This group of students provided an opportunity for the Soundscape Program to capture information about the importance of sound to a unique group of visitors to the Park.

Methods

The students were grouped to have one visually-impaired and one sighted student per team. Using a system of hand signals, the visually-impaired student would relay information to the sighted student about what they were hearing and for how long. The sighted student would interpret the hand signals, and document them on a log sheet with a time stamp from a watch.

Normally, all sounds are logged on a sheet using codes for the different sounds. A key is handy at all times. However, to avoid developing a complex hand signal system that must account for not only the sound source but also the duration, each team was responsible for listening for only four sound sources, generally two natural and two non-natural sounds. If the visually-impaired student on the team did not hear any of the four sounds they were assigned, the sighted student did not record anything on the datasheet. Similarly, if the visually-impaired student heard sounds other than the four sounds they were assigned, the sighted student did not record anything on the datasheet with the assumption that another group would document the sounds they heard. The limited number of sounds that could be documented by each pair of students at one time limits some of the information that can be gleaned from the logs.

At several locations, one or two sighted adults logged all sounds at the same time as the teams of students. These more complete logs allow calculations of noise free interval and total time audible for natural and non-natural sounds.

The hearing range of each observer was not tested. However, no one exhibited signs of hearing loss, and normal hearing was assumed.

Sound pressure level (L) data was collected concurrently with observer logging to determine the amplitude of sounds during the logging sessions. A Larson-Davis 831 sound level meter, Larson-Davis PRM831 preamplifier, and PCB 377B20 microphone was mounted on a tripod at approximately 1.5m above ground level near the loggers. This setup provided continuous 1-second sound pressure levels, measured in decibels (dBA).

Results

Seven locations were monitored along the Colorado River (Figure). Due to weather and time limitations, all but one logging sessions were 15 minutes long. This is a relatively short duration for capturing typical sounds and determining percent time audible for those sounds.

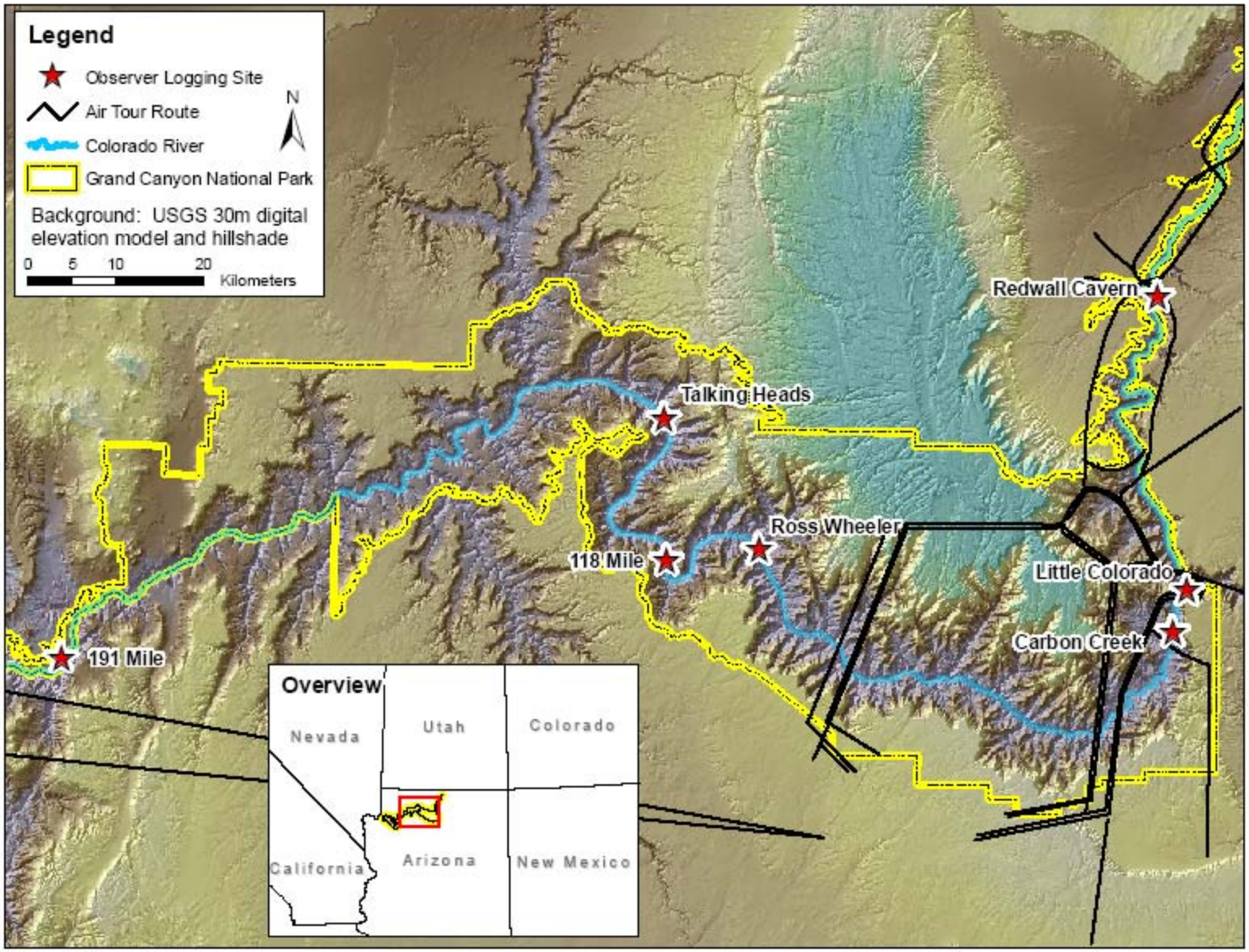

Figure. Observer logging locations along the Colorado River and air tour routes.

Extreme heat dictated that observers be close to the river to log sound sources. River sounds may have masked other sounds that would be audible just a few yards away from the river. However, the heat and lack of shade away from the river did not allow for data collection there.

The sound sources and percent time audible are reported in the Table. When more than one team logged the same sounds, or when more than one solo observer logged, the percent time audible results were averaged. Most of the logging sessions were around the 5pm hour when the group arrived at the campsite. This hour in the day influences some of the sounds heard. For example, most air tour flights are concluding around that time, and most other rafting trips (including motorboats) are in camp already.

River sounds were heard 100% of the time at practically all of the sites. This is probably due to the groups logging very close to the river. The river sounds may have masked other sounds. Insects were also heard much of the time at most sites. Cicadas at dusk can often be loud near the Colorado River.

Propeller planes were heard at only two sites: the Little Colorado and Carbon Creek. These sites are underneath an air tour corridor (Figure), and it is not surprising that these aircraft were heard. Helicopters were documented by the solo logger at Carbon Creek, but not by the teams at the Little Colorado. Perhaps the river sounds masked the noise of the helicopters at the Little Colorado. Only the solo loggers documented high altitude jets, and only at two sites.

People noise is highly variable among the sites and between teams and solo loggers. This could be due to confusion on whether to document camp noise on the datasheets. Some loggers may have ignored the noise, assuming that it should not be documented because it is noise from their own group. Other loggers may have included all people-generated noise.

Total percent time audible for natural and non-natural sounds can be calculated more accurately from the solo loggers because they documented all sounds, and not just four. A minimum of the total percent time audible of sound sources can be calculated from the teams. Because of proximity to the river, natural sounds were audible 100% of the time at all but one site. Total percent time audible of non-natural sounds are highly variable due to the people noise issue discussed above.

Noise free intervals (NFI), or the time between non-natural sounds, could be calculated only from the solo loggers. One hundred eighteen mile site had the longest NFI of five minutes, or 33% of the logging period. However, the total time spent logging was short which may not have captured longer noise free intervals.

The minimum sound level, L_{min}, maximum sound level, L_{max}, and median sound level, L_{50}, are reported in the Table. The sound level meter captured all noise in the vicinity of the device, including the noise generated by people not participating in the logging sessions. Observers noted noise of boats rubbing together, the creak of coolers being opened, and people talking, but may not have logged these noises because they assumed they should not be included in the analysis. However, these noises were included in the sound level data.

Median sound levels ranged from 49 to 67 dBA which are expected sound levels near the Colorado River. Except for 118 Mile, minimum sound levels were within 5 dBA, and more often within 2 dBA, of the median value, indicating that sound levels were close to minimum levels for most of the time period (usually 15 minutes). Talking Heads had a very constant sound level, where the minimum and maximum levels are within 4 dBA of each other, likely caused by the constant sounds of a nearby riffle. Maximum sound levels were not extraordinarily high, and were likely caused from people who were not logging. Sound pressure level data at the Little Colorado River are too low to reflect actual values and are not useable.

Table. Percent time audible, noise free interval (in minutes), and sound levels (in dBA) for each site.

Site		Redwall Cavern	Little Colorado	Carbon Creek	Ross Wheeler	118 Mile		Talking Heads		191 Mile	
River Mile		33	61	65	108	118		133		191	
Date		7/27/2008	7/29/2008	7/29/2008	7/31/2008	8/1/2008		8/2/2008		8/5/2008	
Time		13:09	13:48	17:03	17:12	17:10		17:56		16:45	
Duration		15 min	15 min	27 min	15 min	15 min		15 min		15 min	
Loggers		3 teams	3 teams	1 solo	6 teams	3 teams	2 solo	3 teams	2 solo	4 teams	2 solo
Sound Source	Water	40% (rain)	99% (river)	100% (river)	100% (river)	100% (river)	100% (river)	100% (river)	100% (river)	100% (river)	100% (river)
	Thunder	20%	0%	0%	0%	0%	0%	0%	3%	4%	0%
	Wind	6%	26%	1%	0%	0%	0%	4%	0%	0%	0%
	Insect	0%	100%	22%	100%	100%	100%	63%	39%	100%	100%
	Bird	0%	0%	3%	0%	14%	0%	0%	0%	8%	10%
	Animal (other than bird or insect)	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Rock slide	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Propeller Plane	0%	44%	17%	0%	0%	0%	0%	0%	0%	0%
	Helicopter	0%	0%	56%	0%	0%	0%	0%	0%	0%	0%
	Jet	0%	0%	0%	0%	0%	0%	0%	3%	0%	12%
	People	40%	3%	1%	9%	51%	16%	100%	7%	94%	25%
	Motorboat	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Non-natural (other)			0%		0%	1%		2%		6%
	Total Natural	≥ 40%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	Total Non-Natural	≥ 40%	≥ 44%	70%	≥ 9%	≥ 51%	16%	100%	16%	≥ 94%	42%
NFI (min)	maximum			3.0			5.0		3.3		1.7
	mean			1.1			1.4		1.6		0.7
Sound Level (dBA)	L50	49	*	56	66	67		60		50	
	Lmin	46	*	51	64	55		58		48	
	Lmax	74	*	64	78	74		62		64	

* Sound pressure level data for the Little Colorado site are not usable.

Discussion

This project provided important information for the Soundscape Program. The teams seemed interested in the project, and appreciated the time to "sit and listen to quiet." Most of the sites had a significant amount of non-natural sounds, although how much of that was caused by the group itself is not known.

It is surprising that high altitude jets were not heard by any of the teams, and heard by solo loggers for only short amounts of time. Studies document that jets are heard, on average, about a third of the time in many locations throughout the park (Levy and Falzarano 2007, HMMH 2004, Volpe/Wyle 2004). However, perhaps these groups did not hear or notice them because of the masking effect of the river sounds. Another study (Falzarano and Levy 2007) has shown that river rapids can mask aircraft noise because they both inhabit the lower frequency range of human hearing. Alternatively, the short duration of the logging sessions could have contributed to not hearing high altitude jets.

It is interesting that no helicopters were logged at the Little Colorado site. This is an area of high activity for air tours. Several reasons could explain the lack of hearing them:

1. The 15 minute logging session did not capture helicopter activity.
2. The river sounds masked the helicopter noise.
3. Since each team was responsible for only four sounds, the team responsible for listening for helicopters may not have recognized the noise. The team may have thought it was the sound of an airplane and assumed the team responsible for documenting propeller planes would log the noise.

A comparison of team loggers to solo loggers at the three sites where both logged (118 Mile, Talking Heads, and 191 Mile) is somewhat inconclusive. It appears that team loggers heard sounds for longer periods than solo loggers. This would support the theory that the visually-impaired students had a heightened sense of hearing. However, much of this is for the "people" sound source, which may be influenced by whether or not to include self-generated camp noise.

Recommendations

Several lessons were learned from this pilot project. Some recommendations on future data collection follow.

Longer observer logging sessions

A fifteen minute time period is relatively short to characterize the soundscape of a particular location. One hour logging sessions are normally recommended, but even thirty minutes would suffice.

Vary time of day for logging

Observing the same time period every day may give skewed results because of the patterns of human activity, weather, and animal activity.

Move away from river to log

The masking effect of the river sounds influence what other sounds are heard and for how long. Walking a short distance away from the river to log sounds would provide a better representation of all sounds.

Conduct studies earlier in the season

To avoid the extreme weather conditions in the monsoon season, conduct these studies earlier in the season. This may allow longer observer logging sessions and moving away from the river to log.

Always have a logger documenting all sounds, not just four sounds

Calculations of percent time audible, number of sound sources, and noise free interval are limited when loggers such as the teams listen for only four sounds. If a sound other than the four is heard, it may not be documented, and is therefore missed. It is recommended that at least one observer logs all sounds.

It is still helpful to have several groups logging at once, even if they log all sounds. The results can be averaged, accounting for individual differences in hearing, attention span, etc.

Keep the rest of the group quiet while logging

Others not logging in the group made considerable noise during the logging sessions. It was confusing to the observers on whether to record this information or not. It would be helpful to have the rest of the group keep as quiet as possible when observers are logging. Also, instruct observers on whether or not to include the group's own noise in logging sessions.

Practice

While it may seem to be a simple exercise of sitting and listening, logging sounds benefits from practice. Getting familiar with the datasheets and codes used for logging is helpful to do ahead of time. In addition, getting in the mindset of listening for different sounds may take time. When an observer is habituated to the sounds of society and suddenly thrust into a natural environment, it may take a day or two to notice the birds chirping, water rushing, and a high altitude jet overhead. It may also take time to learn what a helicopter or other unfamiliar source sounds like.

In addition, using the sound level meter takes practice. The buttons to navigate the on-screen menus and acoustic terminology are not intuitive, and require some familiarity before being used in the field. It's best to practice and become comfortable with the equipment in a variety of situations that may be encountered in the field.

Literature Cited

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