THE EFFECTS OF NON-NATURAL SOUNDS ON VISITOR PARK EXPERIENCES IN PUERTO RICO

Report Submitted to:

Professors Dominic Golding and John Zeugner

Puerto Rico, Project Center

By

Ashley Blauvelt	______________________________
Jay Breindel	______________________________
Christina Molinski	______________________________
Zachary Tetreault	______________________________

In Cooperation With

José Alicea Pou, Director of the Noise Control Area

The Noise Control Area, San Juan Environmental Quality Board

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Abstract

Efforts to control noise pollution have focused primarily on urban areas, and there has been little research on noise in parks and nature reserves and very few regulations as result. Sponsored by the Junta de Calidad Ambiental, the goal of this project was to develop an understanding of how non-natural sounds affect visitor experiences in four parks in Puerto Rico. The project team developed sound profiles for each park and conducted visitor surveys to determine visitor perceptions of and attitudes towards noise. The team found that traffic, airplanes, and people were common sources of annoying noise, but each park has its own particular 'noise problem.' Consequently, the team proposed a set of general and park-specific recommendations to help address the problems.

Executive Summary

Noise pollution reduces the quality of life, causes health problems and can limit economic growth. Often viewed as an unwanted side effect of urban living, the Environmental Protection Agency estimates thirty million United States citizens may be at risk of hearing loss from normal ambient noise in a typical urban environment (www.epa.gov). Federal, state and local agencies have been aware of the problem for many years and have passed a wide range of regulations to control noise from the most common sources such as industry, traffic, construction, social events and the natural environment.

National forests, parks, and nature reserves are places people go to seek refuge from the stresses of urban living. Ranging from the vast open spaces of the National Parks like Yellowstone to smaller urban parks, interactions with nature have distinct health benefits and are a proven stress reducer. Unfortunately, noise is a growing problem in many parks and reserves, both urban and rural. In urban areas the sounds from construction, traffic and industry may intrude, whereas in rural areas overhead airplanes, snowmobiles, motor boats and all-terrain vehicles are increasingly of concern. These non-natural sounds are interfering with the natural quiet and serenity that nature has to offer.

The goal of this project was to develop an understanding of how non-natural sounds and unwanted noises affected visitor experiences in the national forests and nature reserves of Puerto Rico. To reach this goal, three main objectives were identified. The first objective was to assess the nature and magnitude of non-natural sounds in four selected parks using fixed and hand-held monitory devices. The second objective was to determine public awareness of and level of concern about non-natural sounds in the selected parks. This measurement of public awareness and concern was conducted simultaneously with the noise measurements and accomplished through visitor questionnaires. Understanding public opinion on noise pollution in nature provided an understanding of which noises, in particular, affect national forest and reserve visitors the most. The final objective was to develop and present a set of recommendations about how to address the problem of non-natural noise in Puerto Rican parks.

To complete the first objective, four parks (Piñones, El Yunque, Humacao and Monagas) were selected based on factors such as visitor attendance, proximity to San Juan, and differences in expected sources of non-natural sounds. In each of the parks, the project team completed thirty minute observational sound logs using the Bruel & Kjaer 2232 to determine a basic list of the

non-natural sounds present and a rough decibel level range for each source. In addition to the sound logs, sound profiles of the park were developed using Norsonic-121 stationary monitoring equipment that was placed in the parks for periods of forty-eight hours. From these data, graphs showing the sound levels in a typical twenty-four hour period were constructed for each park. Using the observational logs and the sound level graphs, the project team was able to interpret and develop an accurate soundscape for each of the four chosen parks.

In order to determine public awareness and level of concern about non-natural sounds present in parks, the project team developed, pretested, and implemented a questionnaire about the impact of these non-natural sounds on visitor experience in each of the parks. The questionnaire was modeled on previous questionnaires developed by Harris, Miller, Miller and Hanson Inc. for use by the National Park Service as well as a questionnaire developed by the Junta de Calidad Ambiental for use in parks in Puerto Rico. The team also compared the survey with ISO standards. The final questionnaire focused on three broad groups of questions. The first group dealt with the details of the participant's current visit to the park while the second group focused on the presence of non-natural sounds in parks and their impact on the visitors' experience. The third group was about the overall level of concern of the issue of noise pollution in Puerto Rico and background information of the participants.

In order for the questionnaire to be completed as accurately as possible, the project team stood at the exit of the main trails to ensure that visitors would have spent an adequate amount of time experiencing the park. A team member would approach the visitors in either Spanish or English, reciting a preamble that ensured them the questionnaire was optional, confidential and anonymous. The collected data was then entered into a database and coded. Non-natural sound sources identified by the visitors were coded into five main categories: automobiles, maintenance, people and radios.

Based on the analysis of the sound profiles and survey data, the project team identified several important conclusions. The first, and possibly the most important conclusion, is that park visitors, in general, feel that noise pollution is an important issue that needs to be addressed. Over 91 % of those surveyed (Figure I) rated noise contamination as either "moderately important," "very important," or "extremely important." This statistic provides justification for continued research on noise contamination.

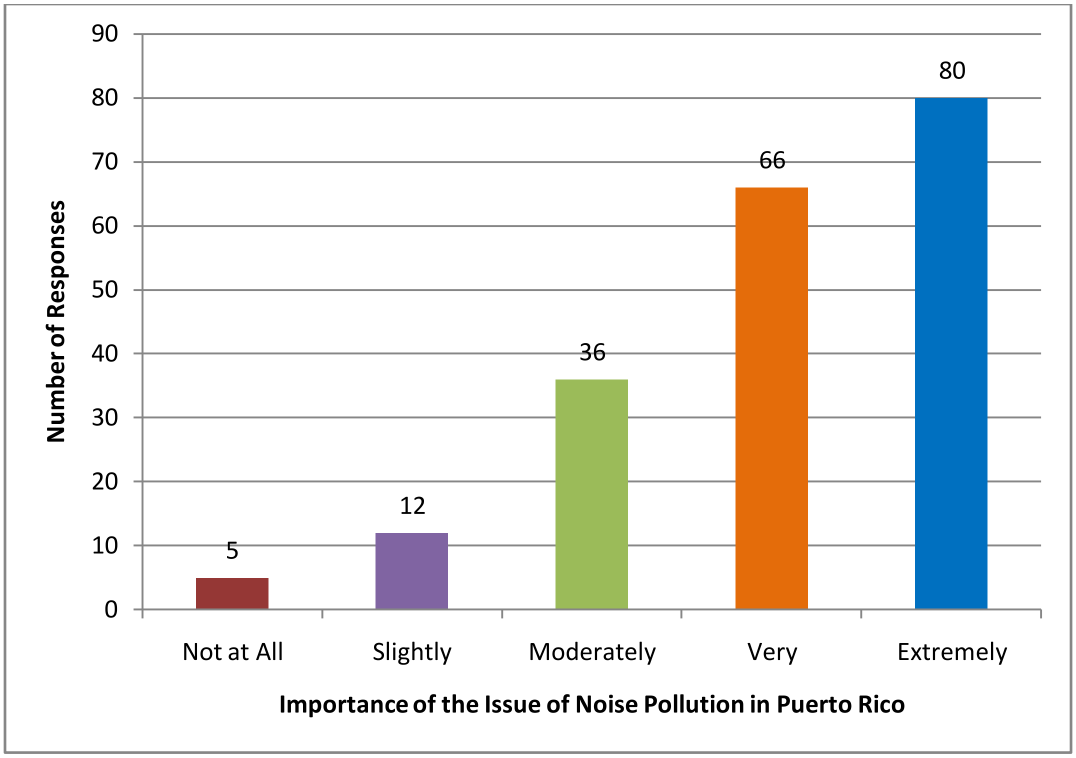


Figure I - Importance of the Issue of Noise Pollution in Puerto Rico

The overall data indicates that ‘automobiles’ and ‘people’ are the non-natural sound sources about which people complain most. Figure II, indicates the overall percentage of visitors complaining about each sound source and the average annoyance level associated with each.

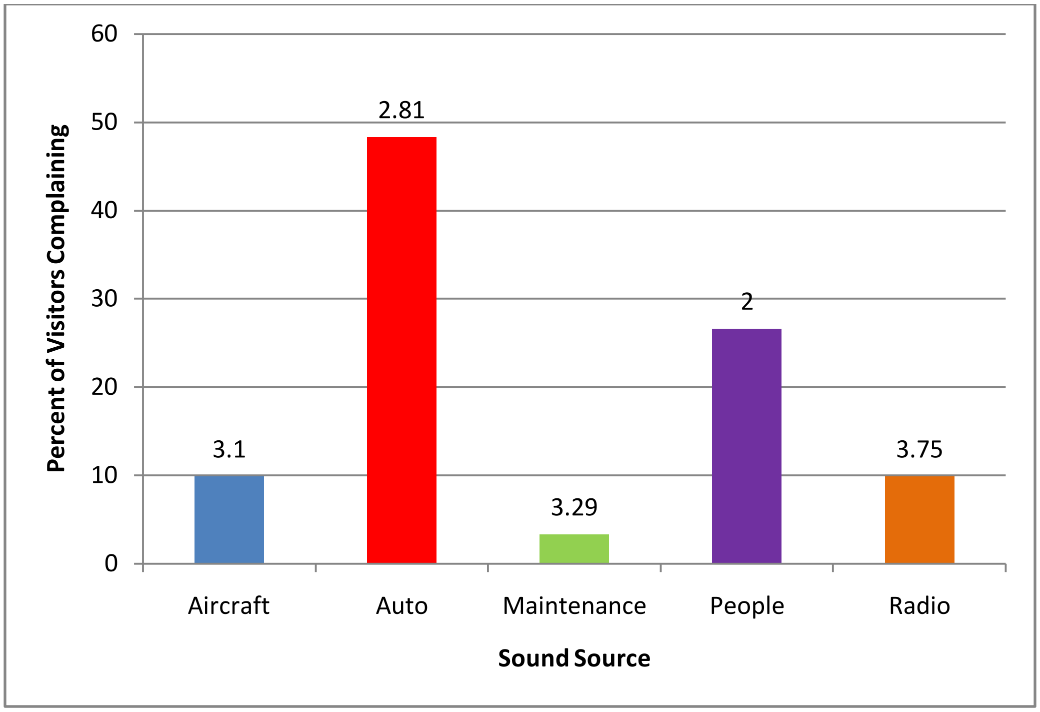


Figure II - Percent of Overall Visitors Complaining by Sound Source

While more people complained about automobiles and people, visitors indicated higher levels of annoyance with the noise from aircraft, maintenance work, and radios. The noise profiles and visitor surveys indicate that each park has its own specific noise problems, as best illustrated below in Figure III.

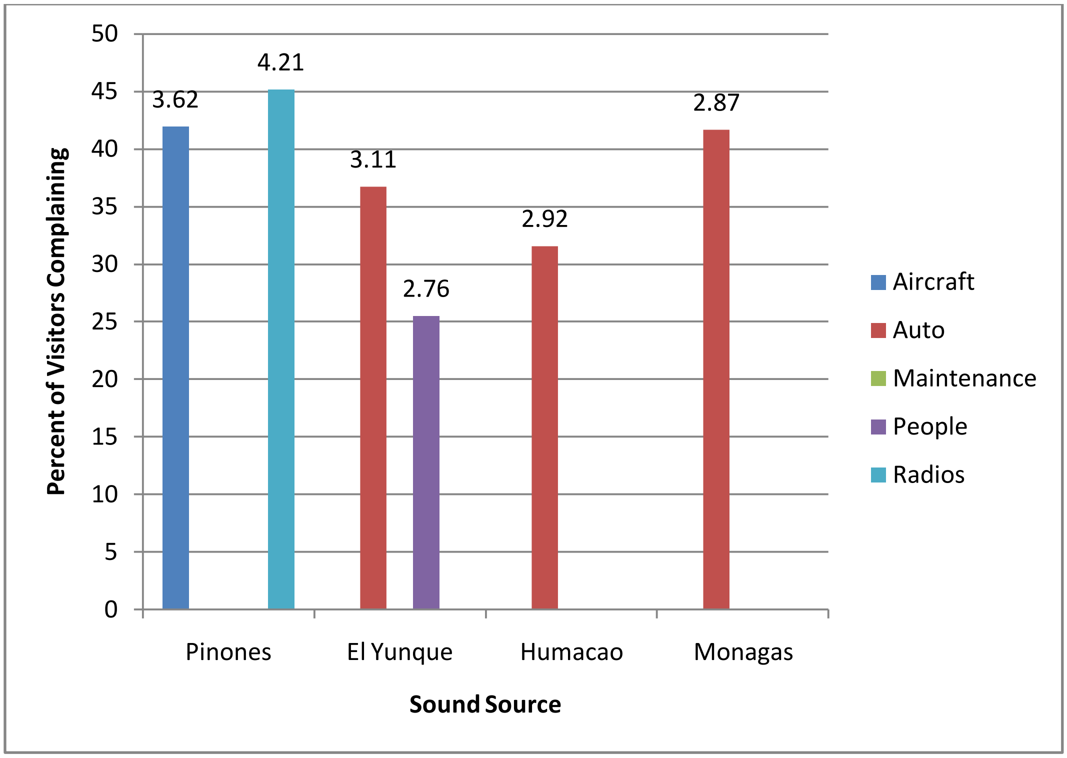


Figure III - Percent of Visitors Complaining by Sound Source with Average Annoyance Levels

In Piñones, aircraft and radios are the most annoying sources of noise while in El Yunque, Humacao and Monagas visitors complain most often about the noise of automobiles. Only in El Yunque is the noise generated by people an issue. By looking at the average annoyance levels associated with each noise source, a trend emerges. With the exception of automobiles in Monagas, there is a near direct correlation of the percent of visitors complaining about a source with its average annoyance level. In Piñones, for example, aircraft have an average annoyance rating of 3.62 with 42% of visitors complaining while radios have an average annoyance rating of 4.21 with over 45% of visitors complaining. This shows more people complain about noises that have higher the levels of annoyance.

The specific soundscapes vary by park according to park size, location, activities and other factors such as proximity to noise sources. From the thirty minute observational logs that were completed, it is clear each park has a different sound profile. Figure IV below, which shows the percentage of each non-natural sound source heard in each park, demonstrates the dominant noise sources for each park based on the sound logs.

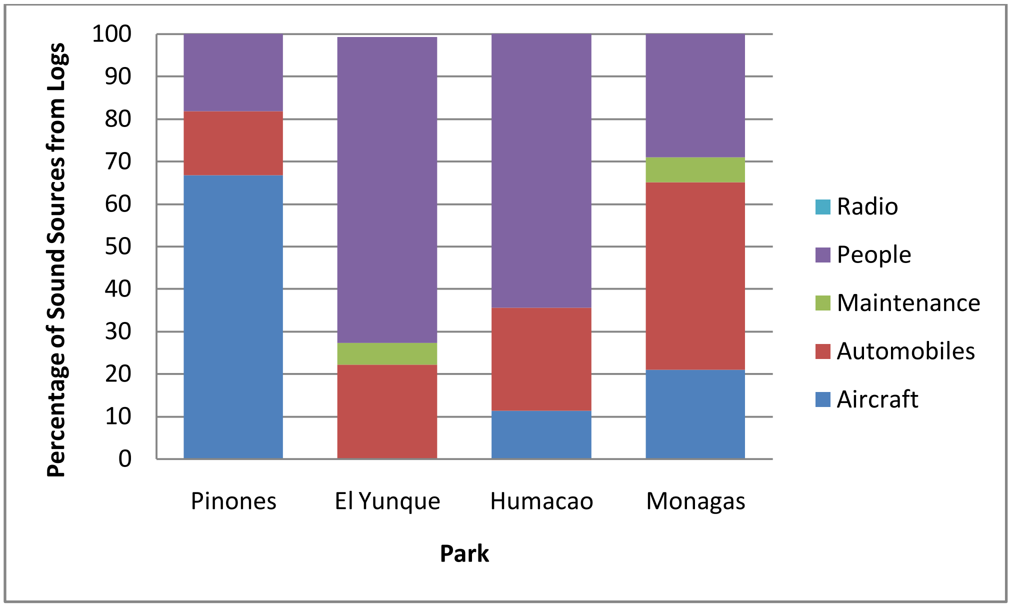


Figure IV - Percentage of Sound Sources from Logs by Park

In Piñones, the most common non-natural sound source is aircraft, which make up over 65% of the non-natural sound. This is compared to El Yunque and Humacao where the dominant source of sound is people, and Monagas where the main non-natural sounds are due to automobiles. Not surprisingly, the particular soundscapes in each park determine what noises cause most concern to visitors.

The research literature indicates and our research corroborates that visitor expectations also shape the levels of annoyance expressed by visitors about particular noises. If visitors expected to hear a sound from a particular source, they had lower average level of annoyance levels than visitors who did not expect to hear sounds from those sources.

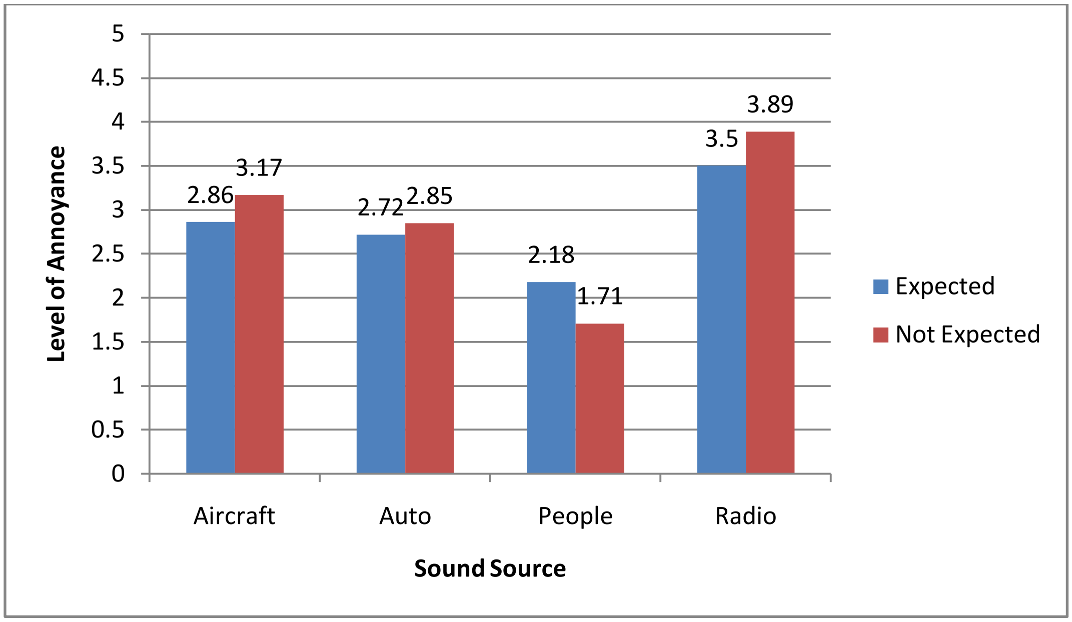


Figure V - Annoyance Levels of Sound Sources Based on Expectation

Figure V shows that if visitors expected to hear radios and then actually heard them, they had annoyance levels that were, on average, 8% lower than visitors that did not expect to hear radios in the park. This same pattern is found with automobiles and aircraft. Surprisingly, visitors who expected to hear other people in the park had higher levels of annoyance with this source of noise than did visitors who indicated they did not expect to hear other people. The project team attributes this to the fact that even if visitors expected to hear people talking, they may still have be surprised and annoyed at how loud people actually were. The monitoring data indicate that the noise of people screaming and shouting nearby often exceeds the noise of aircraft or automobiles.

It is difficult to avoid many of the non-natural sounds such as aircraft noise and people in park settings, but there are still ways to diminish the impacts of noise and enhance visitor experiences. The following are recommendations based on the data and results of this project.

- Deny or limit vehicle access to park roads, except for when absolutely necessary. Instituting a park shuttle system to avoid personal automobile traffic inside or around the park would significantly reduce the amount of automobile noise.
- Challenge visitors to listen for the natural soundscape of the park and see what natural noises they can identify. This may encourage visitors to be quieter, enhance their own park experience, and avoid annoying other people.

- Schedule maintenance work either during non-operating hours for the park or non-peak hours of visitation for the park.
- When noise is unavoidable, inform visitors of what noises to expect prior to their visit in the park. This will help reduce annoyance levels and keep enjoyment levels high.
- Continue research and conduct further studies to develop and defend previous works.

Acknowledgements

This study is a result of collaboration between the Environmental Quality Board of Puerto Rico and Worcester Polytechnic Institute. We would like to thank several people from Puerto Rico and Massachusetts for their assistance in this project. Jose Alicea-Pou, Director of the Area of Noise Control in the Environmental Quality Board, initiated the study with Susan Vernon-Gerstanfeld, the project director for Worcester Polytechnic Institute. Professors Dominic Golding and John Zeugner, the project advisors, aided us in overall research background, methods, and analysis. Nicholas P. Miller from Harris, Miller, Miller, and Hanson Inc. provided immense assistance with background in acoustics and methodologies used in similar projects. From the Junta de Calidad Ambiental (JCA), Olga Viñas, Wanda Cruz, Yamill Brull, and Edwin Borres all assisted in the implementation of the project. Finally, Melina Mendoza Toro, a student from the University of Puerto Rico working as an intern at the JCA, also provided a great deal of help in timely execution of the project.

Authorship Page

This paper was written in a collaborative manner by the entire group, consisting of members Ashley Blauvelt, Jay Breindel, Christina Molinski, and Zachary Tetreault. Each section of this paper was reviewed and edited by all four members of this project team. The project itself was a collaborative effort of all four team members. All team members had an equal and significant part in the writing and completion of this paper.

Table of Contents

List of Figures

List of Tables

Introduction

Noise pollution is a worldwide problem. Especially noticeable in cities and other dense areas, noise pollution reduces the quality of life, causes health problems and can limit economic growth. Often viewed as an unwanted side effect of urban living, the Environmental Protection Agency estimates thirty million United States citizens may be at risk of hearing loss from normal ambient noise in a typical urban environment (www.epa.gov). Federal, state and local agencies have been aware of the problem for many years and have passed a wide range of regulations to control noise from the most common sources such as industry, traffic, construction, social events and the natural environment.

National forests, parks, and nature reserves are places people go to seek refuge from the stresses of urban living. Ranging from the vast open spaces of National parks like Yellowstone to smaller urban parks, interactions with nature have distinct health benefits and are a proven stress reducer. Unfortunately, noise is a growing problem in many parks and reserves, both urban and rural. In urban areas the sounds from construction, traffic and industry may intrude, whereas in rural areas overhead airplanes, snowmobiles, motor boats and all-terrain vehicles are increasingly of concern. These non-natural sounds are interfering with the natural quiet and natural serenity that nature has to offer.

As a commonwealth of the United States, Puerto Rico is subject to federal regulations on noise in addition to its own specific policies. Locally in Puerto Rico, the Junta de Calidad Ambiental (JCA), or Environmental Quality Board, is the government agency responsible for protecting the environment and natural resources. The noise control division of the JCA is in charge of promoting noise policies in addition to establishing and enforcing regulation for the control of noise pollution. There have been a number of previous studies on noise, but only recently has the JCA begun to turn its attention to noise in nature reserves and national forests. The goal of our project is to develop an understanding of how non-natural sounds and unwanted noises affect visitor experiences in the national forests and nature reserves of Puerto Rico. This goal was accomplished by the completion of three objectives; assess the nature and magnitude of non-natural sounds in four selected reserves and forests using fixed and handheld monitory devices, to determine public awareness and level of concern about non-natural sounds in selected parks, and to present the results and provide recommendations of how to address the noise problem in Puerto Rican reserves and forests.

Background Information

Definition of Sound

Often times, the words 'noise' and 'sound' are used interchangeable, but there is actually an important distinction to be made between 'noise' and 'sound.' Simply stated, sound is defined as pressure variations that can be detected by humans or animals (www.nps.gov). Sound is experienced by the human ear through changes in frequency and amplitude.

Noise, on the other hand, is described as loud, unwanted, undesired, or unexpected sounds. Noise pollution referred to as excessive unwanted sounds created as a result of human activities. The term noise can be rather subjective in the sense that sounds that some people do not notice can be regarded as annoying and bothersome by others.

Noise is measured by amplitude and decibels. There are several different levels of decibel measurements, including the L_{eq}, which is discussed here, and the L_{10} and L_{90}, which will be discussed later on.

Amplitude is defined as the difference between the peaks and troughs in a sound wave. Amplitude is normally referred to the loudness of volume of a sound and is typically measured in decibels (dB). In human beings the threshold of hearing begins at 0 dB and the threshold of pain is at around 120-140 dB (http://library.thinkquest.org; http://www.saskatoon.ca/org/municipal-_engineering/attenuation).

L_{eq}, or equivalent sound level, is a very common method of measuring sound levels over time and is recorded in decibels. Sound levels are extremely variable over time, going up and down continuously, making it difficult to record sound measurements. The use of equivalent sound levels is a simple, single sound value for a desired time period averaging the varying sound levels over that time period. The L_{eq} can substitute all variation in sound with one single value of the noise level. For example, a reading of 60 dB indicates that all of the peaks and troughs of sound in a time period is equal to a continuous sound level of 60 dB (EPA 1974). Equivalent sound levels are an easy way to compare average sound levels to one another. Leaves rustling is right around 20 dB(A) , while a typical conversation between people is about

60 dB(A) and a jet taking off would be above the threshold of pain at 150 dB(A). Table 1 shows typical sound levels in dB(A).

Table 1 - Typical Sound Levels (http://library.thinkquest.org)

Sound Source	Decibels	Description
	0	Hearing Threshold
Normal Breathing	10	Barely Audible
Rustling Leaves	20	
Soft Whisper	30	Very Quiet
Library	40	
Quiet Office	50	Quiet
Conversation	60	
Busy Traffic	70	
Average Factory	80	
Niagara Falls	90	Constant Exposure Endangers Hearing
Train	100	
Construction Noise	110	
Rock Concert	120	
Machine Gun	130	Pain Threshold
Jet Takeoff	150	
Rocket Engine	180	

Health Effects of Noise

Noise is everywhere people go, day and night. While the definition of noise is simply unwanted or undesired sound, noise can be more than just annoying, it can have significant negative effects on health. The typical response to noise is to just ignore it, but the ear and the body still responds. Extended exposure to noise can lead to hearing loss and non auditory effects such as high blood pressure, headaches, fatigue and loss of sex drive (Schmidt 2005). All of these effects can be attributed to stress as a result of noise exposure. Stress is the most common result of the constant noise that humans experience and no one is immune to stress (EPA 1978). Stress decreases the body's ability to fight off disease and infection. Nature reserves and forests are places for people to escape from stress, but if there is noise in the area it becomes difficult to do so. Therefore, it is imperative that the reserves' natural quiet is maintained.

When external noises intrude on the soundscape of nature reserves and forests visitors often experience annoyance (Stansfeld 2003). Annoyance can cause feelings of fear, anger, and increased stress levels, usually because noise is viewed as an intrusion of personal privacy (Stansfeld 2003). Annoyance can detract from the visitor experience, and may prevent visitors from returning to the site (www.nps.gov). For this reason, the National Park Service recognizes the importance of protecting the natural soundscapes in National Forests and nature reserves. One objective of the National Park Service is to minimize all noise that may adversely affect the natural soundscape or impact visitor experience in any way (www.nps.gov).

The National Park Service defines a soundscape as the "total acoustic environment of an area" (www.nps.gov). Soundscapes can vary from reserve to reserve depending factors such as varying ecosystems, number of visitors, and location. If there is a large waterfall in a specific reserve or forest for example, then visitors expect to hear louder sounds in that reserve than one without a waterfall. This sort of sound source may be loud, but it is not regarded as intrusive because it is part of the natural soundscape. Soundscapes vary from season to season and from changes in the number of visitors. The level of man-made noise typically increases with an increase in the number of visitors to a park, and ironically this degrades the natural soundscape that many come to experience. In 1998, the National Park Service administered a survey asking visitors to identify the most important reasons for having national parks and reserves and "seventy two percent said 'providing opportunities to experience natural peace and the sounds of nature'" (www.nps.gov).

Noise Control

Federal, state and local agencies have been aware of the problem of noise for many years and have passed a wide range of regulations to control noise from the most common sources such as industry, traffic, construction, culture and the natural environment.

Federal and International Organizations

The Office of Noise Abatement and Control was created within the Environmental Protection Agency (EPA) at the same time that the agency was established in 1970 (EPA 2007). Noise control, however, was not one of the agency's highest concerns. In 1971, when the U.S. Federal Budget was over $200 billion, only $40 million was designated for noise pollution control, which was 1/5th of what was budgeted for air pollution control and 1/40th of that budgeted for water pollution control (Bragdon 1971). In 1972, the Noise Control Act gave EPA full responsibility to control environmental noise through research, monitoring, and regulation. The Agency was charged to protect the population's health and reduce the amount of annoyance presented by noise. The Noise Control Act was amended in 1978 by the Quiet Communities Act, but by 1982 the Office of Noise Abatement and Control was phased out and the responsibility for noise control shifted to state and local governments (EPA 2007). Of all the states, California was the first to make a great effort in addressing concerns with noise pollution. In doing so, the state established several codes regarding motor vehicles and worked with the government to approve a noise abatement program for airports (Bragdon 1971). Shortly thereafter, other states and communities followed suit, creating their own regulations on noise. Currently, the EPA has jurisdiction over all 'federal noise,' such as that from airports, but state and local governments have control over community noise, such as a neighbor's loud radio or motor vehicle (NPC 2007).

Another agency that helps regulate noise pollution is the Occupational Safety Health Administration (OSHA). OSHA sets forth regulations concerning noise, specifically in regards to work environments (OSHA 2007). One of OSHA's objectives it to research the effects of noise in the work place as well as set certain noise regulations to protect the workers' health. To do meet this objective, OSHA has implemented a two-stage program. The first stage is implementing a hearing conservation program in work places where workers are exposed to sound levels above 85 dB in an 8-hour period. Workers' hearing is to be tested once a year and employers are to require their employees to wear hearing protection devices such as ear plugs. The second stage of this program requires that in work environments where noise levels exceed 90 dB, there must be either an engineering or administrative method of noise control. These methods can include such means as reconfiguring the work space to make machinery quieter, replacing machinery with quieter replacements, or mandating how long an employee can be exposed to such noise levels. Failure to comply with OSHA's noise regulations can be quite costly with penalties ranging in fines from $5,000 to $70,000 (www.oshanoise.com 2003).

The World Health Organization (WHO) has also spent a great deal of time conducting research in the area of noise control. WHO has created the World Health Organization Guidelines on Community Noise. The introduction in the guidelines states that "In contrast to many other environmental problems, noise pollution continues to grow, accompanied by an increasing number of complaints from affected individuals" (Burglund et al. 1999). Finalized in 1999, these guidelines include identification of noise sources and measurement, adverse health effects, guideline values, along with noise management and recommendations. For example, the guidelines for outdoor activities during the day, a decibel limit of 55 dB over a period of 16 hours is recommended. The critical effect that is cause for concern is listed as "serious annoyance." Their recommendations for management include both legal and engineering actions as well as education (WHO 1999). These guidelines are an excellent resource for local governments whose goal is to implement noise ordinances in their communities.

State and Local Noise Regulations

State and local regulatory agencies have issued numerous regulations over many years to control noise from various sources. The regulations differ among regulatory agencies, although they typically establish allowable limits for residential, commercial, and industrial settings. Table 2 below illustrates how the zoning is set up in Colorado, for example. It distinguishes between the different zones, the times of day, and decibel level allowed. (NPC 2007)

Table 2 - Maximum Permissible Noise Levels in Colorado (NPC 2007)

Zone	**Day time (7am - 7pm)**	**Night time (7pm - 7pm)**
Residential	55 dB(A)	50 dB(A)
Commercial	60 dB(A)	55 dB(A)
Light Industrial	70 dB(A)	65 dB(A)
Industrial	80 dB(A)	75 dB(A)

Residential areas are areas where humans dwell or consider a place of tranquility such as a church. Commercial areas contain places of business or education while industrial areas are considered warehouses, factories, or military bases. Both the EPA and the WHO have set sound limits of 55 dB(A) as the 24-hr L_{eq} for outside areas to minimize annoyance.

Noise from motor vehicles is one of the most commonly regulated sources. In Puerto Rico, a group known, in English, as the Interagency Committee and Citizens Above the Noise (CICAR) gathered public opinion through a survey about environmental noise. They found that the most common noise complaint was motor vehicle noise (Junta de Calidad Ambiental, 2007). Accordingly, Junta de Calidad Ambiental, has placed some regulations on motor vehicles in response to the number of complaints they have received. In January of 2000, Ley de Vehiculos y Transito de Puerto Rico, which translates to Vehicle and Transportation Law of Puerto Rico, was put into effect. This law covers all of the matters related to traffic and motor vehicles. For example, the law stated that anyone who modifies the muffler on a vehicle to make it louder will be issued a fine (Alicea-Pou 2004). Other policy options include controlling the speed of vehicles in designated places, such as residential areas or parks, since reducing vehicle speed has a dramatic impact on noise. For example, James Cowan (1994, p. 150) notes that "reducing vehicle speeds from 40 to 30 mph is as effective at reducing noise as removing one half of the vehicles from the roadway."

Besides motor vehicles, regulations have been issued to control noise from musical devices, pets, construction, places of entertainment, and firearms/explosives. Violation of the laws concerning these items also varies in each state. Usually a complaint must be made in order for legal action to take place. A fine or other penalty may be issued depending on the severity of the action. (NPC 2007).

There are many similarities between noise legislation enacted in Puerto Rico and the continental United States. For example, Junta de Calidad Ambiental has set noise levels for residential, commercial and industrial zones (Table 3) that are similar to those set in Colorado (Table 2). JCA has established regulations for an additional zone. Zone 4 is the "Quiet Zone" and includes areas such as hospitals and courts of justice. The JCA defines emitting source as "any object, device, or sound wave originating device, such as of a fixed type, mobile, or portable." In Table 3, the zones below the emitting source are where the sound source is located while the zones below the receiving zones are where the emitting source is heard.

Table 3– Noise Level Limits in Puerto Rico (JCA 1987)

EMITTING SOURCE	RECEIVING ZONES							
	ZONE 1 (Residential)		ZONE 2 (Commercial)			ZONE 3 (Industrial)		ZONE 4 (Quiet)
	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime	Daytime	Nighttime
ZONE 1 (Residential)	60dB	50dB	65dB	55dB	70dB	60dB	50dB	45dB
ZONE 2 (Commercial)	65dB	50dB	70dB	60dB	75dB	65dB	50dB	45dB
ZONE 3 (Industrial)	65dB	50dB	70dB	65dB	75dB	75dB	50dB	45dB

Most of the regulations that have been discussed thus far have to do with urban and residential areas. Very little has been done to regulate noise contamination in parks, though. In fact, not many studies have been done in parks and reserves, hence the lack of regulations. More research regarding non-natural sounds in nature needs to be done. The following section discusses the importance of parks and natural quiet along with common noise sources and how noise has a negative impact on visitor experience.

Benefits of Nature

Natural resources, such as national forests and nature reserves, are very important for a variety of reasons. One aspect that is very important, if not most important, to most people is a reserve's ability to relieve stress (Mace, Bell, and Loomis, 2004; Gramann 1999; Driver et al. 1991). In fact, according to Wolf (2000) when nature has been used as a remedy for stress, people have shown both psychological and physiological improvements. In a study conducted by Ulrich et al. (1991), time spent viewing and experiencing nature had been shown to reduce blood pressure, reduce muscle tension, and restore concentration and attention spans. Even small doses and short visits to reserves or forests can have valuable affects (Wolf 2000). It is a very common theme in scholarly reports that nature reserves and national forests are beneficial and restorative environments (Berto 2005; Kaplan 1995; Mace, Bell, and Loomis 2004; Ulrich et al. 1991; and Wolf 2000). In fact, it is mentioned in Berto (2005) that parks, even urban parks, reserves, and forests are restorative environments while cities and other urban areas are stressful environments. Thus, parks are very important for healthy, liveable communities.

The natural quiet of nature reserves and national forests is a great value to people both after stressful events and prior to them. Wolf (2000) notes an "immunization effect" which is experienced after a visit to a nature reserve or forest. The stress relief and calmness that is offered carries over into future events, making stressful situations less stressful. This "immunization effect" can really benefit one's health and overall stress level. Negative events in life can lead to increased stress, which will then lead to worse physical and mental health as shown in Figure 1. Avoiding the full consequences of these negative events is one of the most important benefits a natural setting, such as a nature reserve, can provide.

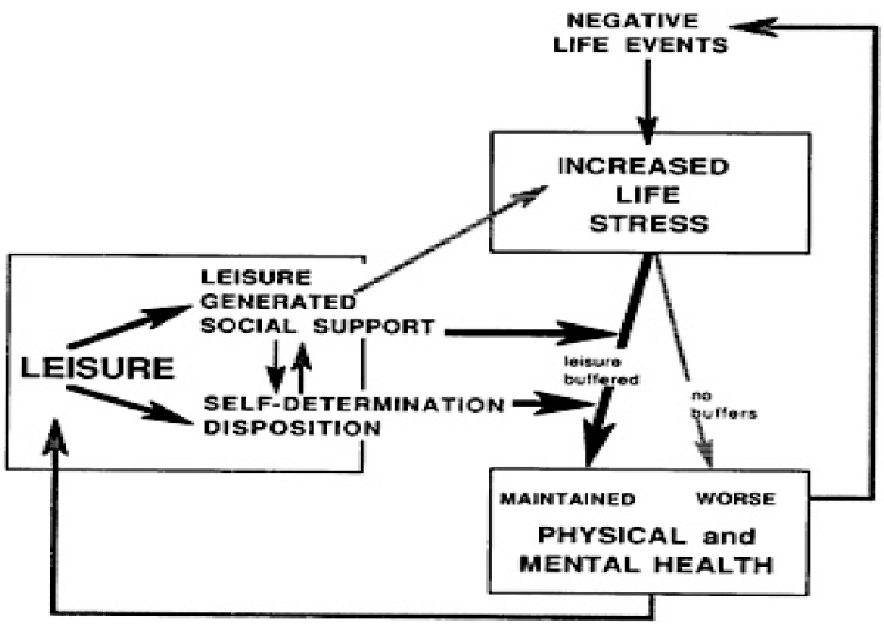


Figure 1 - Leisure-stress buffering cycle

Health benefits are not the only benefits of visiting reserves and forests. Having a scenic view as part of one's daily routine can also help one's performance in work and in studies. In a study completed by Tennessen and Cimprich (1995, as cited in Berto 2005), students who had a more scenic view performed better on exams than students with a less scenic view.

According to McDonald, Baumgartner and Iachan (1995, as cited in Mace, Bell, and Loomis 2004), ninety-one percent of nature reserve and national forest visitors felt that natural quiet and natural sounds very valid as a reason to visit parks. Almost every person has their own personal reasons for visiting reserves, whether it is to relieve stress, to exercise, or even to just enjoy the beauty of the landscape. Unfortunately, the loss of natural quiet and natural sounds creates substantial annoyance to the nature reserve and national forest visitors (Gramann 1999). Avoiding the consequences and the loss of reserve experience that accompanies lack of nature is very important. External noises are directly correlated with the loss of natural quiet in reserves and forests. Too much automobile traffic, air traffic, loud music, and other unnatural noises can drown out the sounds visitors associate with nature. These consequences from external noises lead to noise regulations and other techniques to keep unwanted noises out of nature reserves and national forests.

Sources of Noise

It is clear that external noise often has a negative impact on visitor experience and interferes with the positive effects of parks and nature reserves. External noise can come from any number of sources depending on the park itself. The following paragraphs describe in more detail some of the common sources of noise that many park visitors find bothersome.

Characterization of Noise in Nature Reserves

As stated before, noise is considered unwanted, unexpected, and annoying sounds. In parks, noise is anything that takes away from the natural soundscape of the nature reserve. The types of noises that are most commonly complained about in reserves and national forests include aircraft overflights, traffic, and construction noises. Table 4 provides examples of different levels of sound heard in National Parks.

Table 4 – Amplitude Levels

Sound	dBA
Threshold of human hearing	0
Haleakala NP: Volcano crater	10
Canyonlands NP: Leaves rustling	20
Zion NP: Crickets (5 m)	40
Whitman Mission: Conversational speech (5 m)	60
Yellowstone NP: Snowcoach (30 m)	80
Arches NP: Thunder	100
Yukon-Charley Rivers NP: Military jet (100 m AGL)	120

Each National Park has its own distinguishing characteristics and with these come other noise sources.

Aircraft Noise

The most common and most studied source of external noise in reserves is aircraft engines. The number of commercial passenger flights, general aviation, military and emergency operations have all increased dramatically in recent years (www.nps.gov). Many of the flights over the National Parks are helicopters or planes giving aerial tours. These tours are limited by The National Parks Air Tour Management Act of 2000 which requires all parks, reserves, and forests with aerial tours to have a Commercial Air Tour Management Plan but are becoming more and more popular.

Airplanes flying over reserves and forests are an annoyance and a distraction to many visitors. According to a report to congress by the National Park Service, 53% of 273,465,349 recreational park visitors reported concerns about aircraft over-flights (National Park Service, 1994). The National Park Service estimated that there are over 35,000 over-flights in national parks per week. There are a few options to look at that would successfully reduce the impact aircraft over-flights have on nature reserve and national forest experiences.

- Flight-free zones can be established over reserves and forests. The problem with this idea is that the zones would have to be large, 20-30 miles in each direction (National Park Service, 1994).
- Increase the number of passengers per flight and thereby reduce the number of flights. This change does not take away the noise, but the intrusions would be less frequent.
- Breaking the line of sight between the aircraft and the visitor will effectively reduce the maximum noise levels heard by the visitor.
- Set limitations on over-flight altitudes. Enforcing a minimum altitude would help the issue, but it is very unlikely that this implementation alone will solve the noise problem presented by aircrafts.

In regard to federal noise legislation, the U.S. government has launched a few acts in response to airflights. In 1987, the Parks Overflight Act was established to reduce the amount of tours and commercial flights flying over national parks during the day. It was not enforced enough to show overall improvement in natural sounds being heard, though (Faehner 2007). The natural sounds in such national parks as the Grand Canyon has actually decreased since the act was installed. A decade later, a new National Parks Overflight Act was built upon the previous legislation to give equal authority to the National Park Service instead of sole authority of the Secretary of the Interior (Robinson 1997). In 2000, the Air Tour Management Act was set up and required that all commercial planes and helicopter tours authorize themselves with the Federal Aviation Administration (FAA). However, the FAA had been uncooperative with the National Park Service concerning all such enforcement (Faehner 2007). Another attempt in 2000 was an amendment to the Aviation Noise Abatement Policy. The FAA expressed interest in using new technology to alleviate the impact of noise. One specific goal was to design air traffic routes with respect to noise sensitive areas, such as national parks (Connor 2000). The Federal Aviation Administration has the authority to determine how airport noise should be managed, but reducing aircraft noise conflicts with the FAA's main goal of promoting the growth of the aviation industry (Schmidt 2005).

Traffic Noise

Motor vehicles are a major source of noise complaints. The noise from vehicles is often caused by loud or altered mufflers, car horns, and simply high traffic volumes. There are several options in mitigating traffic noise that should be considered such as traffic noise barriers and reducing the speed limit.

Highway traffic noise barriers are simply solid objects that are built between a highway and whatever happens to be bordering it (www.fhwa.dot.gov). Sound barriers do not make the noise disappear, they only reduce it. An effective barrier can reduce noise, though, by up to 10 decibels (dB). These barriers are usually either earth mounds, commonly referred to as "berms," or vertical wooden walls. Earth mounds are much more aesthetically pleasing and slightly more effective, reducing 3 dB more noise than walls of the same height, but require more earthwork, especially if they are really tall. Wooden walls are much easier to construct and require a lot less land.

Noise barriers alongside busy highways are successful in reducing noise to residents living on the other side of the barrier provided it is constructed properly. In order to be effective, barriers much be higher than the receiver's line of sight. With each additional meter of height above the line of sight, 1 dB of sound is reduced.

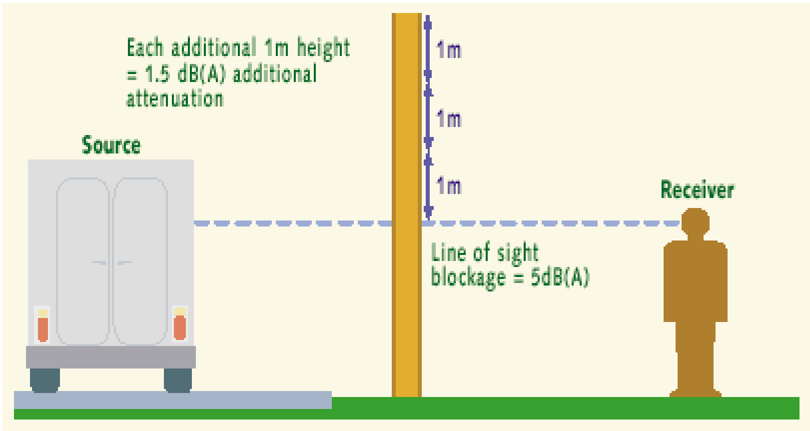


Figure 2 - Noise Barrier Effectiveness (www.fhwa.dot.gov)

They must also be 8 times as long as the distance between the receiver and the barrier in order to avoid noise coming around the sides of the barrier. Any openings in the barrier would completely destroy the effectiveness of the barrier.

Public opinion on noise barriers is, for the most part, positive. Residents with homes near a highway with a sound barrier seem to find the barriers effective in reducing noise, allowing them to open their windows more, sleep better, and feel more privacy (www.fhwa.dot.gov). There are, of course, some negative feelings towards such barriers like feelings of confinement, obstruction of view, and loss of sunlight.

Another option in mitigating noise caused by traffic is to make sure drivers are aware that they are near a nature reserve or national forest. Roadside signs should be used to inform drivers that the use of horns is prohibited in areas near reserves and forests (Zannin 2005). An alternative idea, currently being employed at Zion National park, is the use of a shuttle system for park visitors (www.nps.gov). Visitors park their vehicles further away from the park and a bus transports park goers to the entrance of the park. The shuttle system has resulted in a noticeable reduction in motor vehicle sound levels. As stated before, reducing the speed limit can have a dramatic impact on the sound level caused by traffic (Cowan 1994).

Construction

Construction is certainly part of the noise problem, yet many people do not always think of it as a problem because for the most part, construction projects are temporary. It is not easy to determine exactly how much construction contributes to noise pollution due to the day to day variations and varying shift lengths (Eaton, S., 2000), but when construction is occurring it certainly does not go unnoticed by people nearby. Noise from construction projects in or near nature reserves can easily interfere with a visitor’s experience. Addressing the noise caused by various construction projects in or around nature reserves is very important. According to a report done for the Workers’ Compensation Board of BC by Stuart Eaton (2000), possible noise mitigation options include:

- Requiring tools used on construction sites to follow guide lines indicating maximum noise emissions.

- Requiring that on-site inspectors make sure that tools are maintained and that workers do not work outside site boundaries.
- Prohibiting construction activity by time of day and specific dates.
- Creating guidelines as to when trucks can come through and how many trucks are allowed.
- Requiring construction sites to use proper sound barrier techniques to reduce the noise heard outside of site boundaries.

Other Noise Sources

Depending on the location and type of nature reserve or national forest, there are several other sources of noise. Popular sources for noise complaints include snow mobiles, personal water crafts like jet-skis, recreational boating and automobiles (www.nps.gov).

Personal watercrafts such as jet-skis produce sound levels in between 85 and 105 dB(A) (www.nps.gov). Jet-ski noise emissions have been such an issue in some parks that some have banned the use of jet-skis. Acadia National park in Maine was the first national park to ban jet-skis in 1998 because of the number of noise complaints (Bangor Daily News 1998). Currently, 66 national parks do not allow the use of personal watercrafts because of disruption due to excessive noise (www.nps.gov).

Snowmobiles are another common cause of visitor complaints in several national parks throughout North America. The National Park Service attempted to phase out the use of snowmobiles in Yellowstone National Park in 2000 to control both noise and air pollution. The plan was to replace the use of snowmobiles with snow coaches, but in 2004, the National Park Service issued a report that there was not any significant difference as a result of using snow coaches. Currently, up to 720 snowmobiles are allowed in Yellowstone, all commercially guided though (www.nps.gov). The NPS is still working on coming up with alternative methods of managing snowmobile use.

Conclusion

Noise pollution is a serious problem that needs to continue to be dealt with. Noise has adverse consequences on humans and has a tendency to raise already high stress levels. It seems that noise is everywhere we go and there needs to be some sort of escape. Nature reserves and national forests should be able to provide that break from the noisy world that people need, but it appears that these areas are unable to do so. Noise pollution is infiltrating reserve and forest boundaries, ruining the natural quiet people have come to expect. As a result, visitors' experiences in nature reserves and national forests are often negatively impacted.

Methodology

Noise is generally viewed as unpleasant and annoying, especially in nature. Forests and nature reserves are expected to be peaceful and to have a natural quiet, but this is often not the case. Non-natural sounds and unwanted noise enters nature and damages the natural quiet. Noise detracts from visitors' overall outdoor experiences. The goal of this study was to develop an understanding of non-natural noise in national forests and nature reserves as well as how such noises affect the overall visitor experience in selected reserves in Puerto Rico.

In order to reach this goal, three main objectives were identified. The first objective was to assess the nature and magnitude of extraneous noises in four selected reserves and forests using fixed and hand-held monitory devices. The second objective was to determine public awareness of and level of concern about non-natural noises in the selected parks. This measurement of public awareness and concern was conducted simultaneously with the noise measurements and accomplished through visitor surveys. Understanding public opinion on noise pollution in nature provided an understanding of which noises, in particular, affect national forest and reserve visitors the most. The final objective was to present our results and provide recommendations about how to address the noise problem in Puerto Rican forests and reserves.

Noise Assessment

In this section, methods regarding noise assessment such as the selection of forests and reserves of interest and techniques of noise monitoring will be discussed in depth.

Park Selection

In Puerto Rico, there is one national forest, El Yunque, and about seventeen other protected reserves throughout the island. The complete list of parks and reserves is documented in the matrix shown in Appendix B. In consultation with staff at the JCA, we chose four parks/reserves where we monitored noise levels and surveyed visitors. The parks were selected based on a set of criteria, including: proximity to major highways and airports, the size of the park, ecosystems represented, and the annual number of visitors. As shown in the matrix, the parks in Puerto Rico cover a wide range of ecosystem types from tropical rainforest to dry forest and mangrove swamps. Since El Yunque is the only true tropical rainforest in the United States, it was the first location we selected. In selecting the other three parks, the project team had to consider other factors including proximity to San Juan and visitor attendance. The team at one point considered using Bahia de Jobos, but after visiting the reserve, it was clear that team would be unable to gather sufficient data in the time available since the park is located more than 50 miles from San Juan and has relatively few visitors. The three other parks that were selected were Piñones, Humacao, and Monagas. Each of these three locations were within an hour drive of San Juan and had enough visitors, specifically on the weekends, to complete surveys. See appendices G through J for more general information on the selected locations. Figure 3 is a map of Puerto Rico the location of the selected parks.

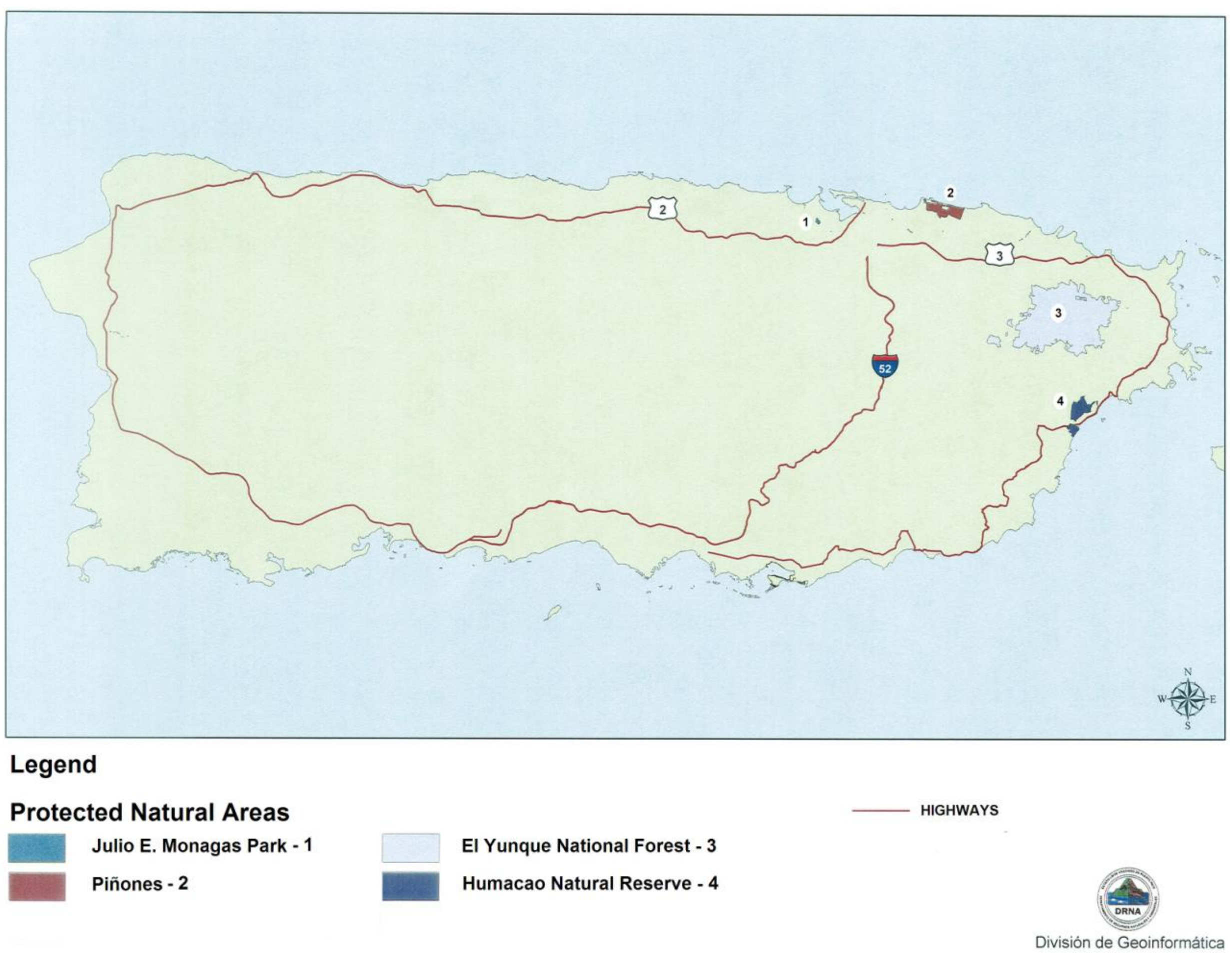


Figure 3 - Location of Selected Parks in Puerto Rico

Table 5, shown below, lists the four locations selected for this project along with a little bit of information about each. Piñones, for example, has a moist tropical ecosystem and is exposed to aircraft noise as well as traffic noise, while El Yunque is a tropical forest with traffic noise but no exposure to aircraft noise. Having parks and reserves that are exposed to sound sources such as aircraft and traffic was important in order to see how much such noise sources interfere with visitor experience.

Table 5 - Park Selection Matrix

Park	Ecosystem	Visitation	Aircraft Noise	Traffic Noise	Distance from San Juan (mls)
Pinones	Moist Tropical Forest	Low	Severe	Yes	~5
El Yunque	Tropical Rainforest	High	Minimal	Yes	~25
Humacao	Pterocarpus Forest & Lagoons	Moderate	Minimal	Yes	~45
Monagas	Moist Tropical Forest	Low	Moderate	Yes	~10

Noise Monitoring

The first step in ensuring an accurate and complete noise profile is determining the best location for the monitoring devices. Prior to setting up the monitoring devices, the project team and JCA staff walked around each location and observed where the visitors spend their time, placing the devices near the busier areas. It is important to note that the more out of sight the recording devices were the better. If the devices are set up in plain view, many of the visitors will take an interest in the device and the results could be jeopardized by the visitors interfering with the monitoring devices or asking questions of the survey team. This conversation would be picked up and would jeopardize the data collection. Consequently, the team set up the sound equipment close to the path, yet well hidden from park visitors.

The three noise monitoring devices the project team used were the Norsonic-121, a Bruel & Kjaer 2236, and the Bruel & Kjaer 2232 (Figures 4, 5, & 6 respectively below). The Norsonic-121 is a larger device that is used to record the sound level of an area for extended periods of time. The Norsonic-121's were chained to an anchor, such as a tree, to ensure that it was not stolen. All sound levels were recorded by their A-weighted values continuously over a 48-72 hour period. The Norsonics were set up in their selected locations and left there for 2-3 days. At the end of the recording period, they were picked up and the data was saved to a computer to be analyzed at a later time. This system takes into account the different effects various levels of sound can have and is the best system for mimicking the way the human ear hears. The Norsonic-121 records sound data on various different scales and levels, but the project team was only concerned with the L_{10}, L_{90}, and L_{eq} levels which are explained in the results chapter. The team recorded data with the Norsonic-121s on the dates indicated on Table 6.

Once data was collected, the Norsonic-121 data was broken up into separate 24 hour periods and then averaged together to produce one single graph depicting a typical 24 hour sound level graph based on four to ten separate 24 hour periods depending on the location. Table 6 illustrates the amount of data that was collected in each reserve or forest.

Table 6 - Norsonic 121 Data Collected

Location	Dates Recorded	Number of Stations	Number of 24 hour periods
Pinones	3/15 - 3/17	1	2
	4/13 - 4/15	1	2
			Total - 4
El Yunque	3/18 - 3/20	4	7
	4/1 - 4/2	2	2
			Total - 9
Humacao	3/26 - 3/28	3	6
			Total - 6
Monagas	4/9 - 4/11	2	4
			Total - 4

It is important to distinguish that the data obtained from the Norsonic-121 was used to create a general soundscape of the location while the observational logs that used the Bruel & Kjaer handheld monitors were used to identify particular noise sources and decibel ranges. The Bruel & Kjaer 2236 is a handheld device that monitors the environmental noise and frequency analysis of sound sources. It was used as a reference and for the following observation logging in Piñones only. After monitoring in Piñones, the project team switched from the Bruel & Kjaer 2236 to the Bruel & Kjaer 2232 for the remainder of the parks due to technical issues with the Bruel & Kjaer 2236. The monitoring devices were provided by the Junta de Calidad Ambiental and the procedure was completed in cooperation with the agency, incorporating any changes that were deemed necessary.

Figure 4 – Norsonic-121

Figure 5 - Bruel & Kjaer 2236

Figure 6 - Bruel & Kjaer 2232

Simultaneously with the noise monitoring, two team members kept a sound log. This log contains the source of the sounds heard by our group member and what time they occur as well as the sound level in dB(A). Two team members walked just a few feet from the side of a trail used by nature reserve visitors so that the sound log reflected actual data heard by visitors walking along the paths in the reserves. Each log was kept for 30 minutes at a time. Prior to starting each sound log, location, time of day, and weather was noted. A sample log can be found in Appendix E. One team member held the Bruel & Kjaer hand held sound reader while the other team member kept the log. At the start of the thirty minutes, the background sound level was recorded. The background sound level was recorded when there were no other sounds except for those that were constant. A sound source was recorded whenever the Bruel & Kjaer registered sounds louder than the background noise level. The sound source itself was noted alongside the decibel reading and, as was already mentioned, this went on for thirty minutes at a time. Once the logs were completed, the data was entered in to a computer for easy access. The logs provided the team with an understanding of what the specific sound sources were in each specific location. Table 7 below shows the amount of log data accumulated as well as on which date and location.

Table 7 - Sound Log Collected Data

Location	Dates	Number of Logs
Pinones	13-Mar	2
	20-Apr	2
		Total - 4
El Yunque	18-Mar	3
	2-Apr	2
		Total - 5
Humacao	24-Mar	2
	27-Mar	3
	31-Mar	1
		Total -6
Monagas	29-Mar	2
	4-Apr	2
	19-Apr	1
		Total -5

Determination of Public Awareness

In this section, methods regarding the determination of public awareness are discussed in more detail. These methods include interviews, continued archival research, and the development, implementation and content of questionnaires. This section also discusses the data coding and analysis for this project.

Interviews and Continued Research

Researching public awareness of noise pollution has been an ongoing study for numerous years. There have been many reports and standards written about noise pollution and how it affects park visitors. Continuous research of these previous reports, projects, and their findings was crucial for our project team. Knowledge of previous successes and failures allowed our group to have a better understanding of the assignment and an opportunity for a more successful project. Information gathered from these reports and other continued research of previous studies and results helped with understanding current regulations and analyzing data that was collected.

Survey Development

With the help of the JCA and other experts, the team created and pre-tested a questionnaire to distribute to park goers in order to gain feedback on how non-natural sounds affected their outdoor experience. This survey, as shown in Appendix C and D, English and Spanish version, respectively, is modeled on questionnaires distributed by agencies such as the National Park Service, the sound consultants Harris Miller Miller & Hanson Inc., and the JCA. The team pretested and modified this questionnaire with members of the JCA by comparing the project team's survey with the JCA's in-house survey. The questionnaire was also compared to the ISO standards as shown in Appendix N.

In the forests and nature reserves, team members approached adult visitors to seek their participation in the survey. The members of the survey team introduced themselves as students from WPI and explained the nature and purpose of the survey. The content of this preamble was modeled on examples provided by Harris Miller Miller & Hanson Inc. and is shown in Appendix C and D. The preamble was also printed at the beginning of the survey in order to allow the participant to return to it if they wished to read the preamble again. If the visitor refused to participate, the team thanked them for their time and marked down that there was a refusal. Marking down refusals allowed our group to determine a refusal rate for each park and then determine how much the refusal rate affected data collection. If the visitor agreed to fill out the questionnaire, then the team members handed them the survey on a clip board and asked that the participant answer the questions immediately and then return the questionnaire with their answers to the team member. With the help of the JCA, the survey and preamble were written in both English and Spanish which allowed for visitors speaking either language to participate. Providing both an English and a Spanish version of the questionnaire allowed participants to fill out the survey in whatever language was more comfortable. Another way to the team broke through the language barrier was by having both a student who spoke English and a student who spoke Spanish conduct the surveying. Being familiar and comfortable with both languages allowed for easy communication if the visitor had any questions or concerns about the survey.

Our method of distribution was a non-probability method. The "convenience method," as described in Berg (2007), is a surveying technique used to survey any participants that are available. Since there was not much park visitation in any of the chosen parks, the team surveyed every visitor that was available. When there was a larger group of visitors, the team concentrated on the adults in the group in order to allow for more educated responses and more participation. A younger visitor might have been more hesitant to participate in our project and had less of an understanding what the project entailed.

Survey Implementation

The project team positioned themselves either by the park exits or the exits to major trails in the park in order to survey visitors after their visit. The choices of locations were directly dependent on the park layouts. Some parks had well defined exits while others did not. The different park layouts were brought into consideration when deciding where to conduct the surveys and it was necessary to interview the park personnel on the best locations. The park personnel were helpful because they had the most knowledge on the park layout and attendance rates. Occasionally, the problem of refusals occurred when attempting to speak with visitors as they were leaving. It was difficult to survey park visitors when they were in a rush to leave the park. When this problem occurred, the visitors who did not participate in the survey were recorded as refusals.

The project team surveyed any visitors that were in the parks during our visits that agreed to fill out the questionnaire. The team performed anonymous surveys and did not request names or specific addresses. In order to have the best selection of visitors, the project team spoke with park personnel to determine when the parks were busiest. The team then scheduled the surveying to be conducted during the times when the most people were visiting the park. Working during the busiest hours in parks allowed for a rapid collection of a sufficient amount of surveys to compensate for the short term of the project. This often meant working on weekends in the reserves that had low visitor attendance during the week.

The team spent about a week in each of the four chosen parks. After original discussions with the JCA, the project team decided to set a goal of one hundred completed surveys per park. The number of questionnaires used was strongly determined by the results the JCA expected from the project and also the results the team expected. The final number of surveys was limited by how many visitors completed the questionnaires during the time available for the team to conduct surveys at each site. After initial struggles with the amount of park attendance and availability of transportation, the goal of the project team was ultimately lowered to thirty questionnaires per park. On each survey the project team recorded the time, the date, and the location in which the questionnaire was completed. Table 8 shows the number of surveys collected in each location and on which dates. The team collected sound data simultaneously with sound monitoring, which allowed the team to compare the survey information to the recording logs and monitored sound data. The comparison of this information allowed us to analyze how different locations and times were affected by different levels of non-natural sounds.

Table 8 - Survey Collected Data

Location	Dates	Number of Surveys
Pinones	6-Apr	5
	13-Apr	17
	20-Apr	8
		Total - 30
El Yunque	17-Mar	28
	18-Mar	42
	2-Apr	28
		Total - 98
Humacao	24-Mar	10
	27-Mar	4
	31-Mar	3
	5-Apr	21
		Total - 38
Monagas	29-Mar	16
	5-Apr	2
	19-Apr	13
		Total - 31

Survey Content

The complete survey, which can be found in Appendix C and D, consisted of numerous questions which gave us information on how noise levels and noise sources affected different people and different locations. First, the survey asked the date and time of arrival for the current visit of the participant. Knowing the time of the interview, we were able to calculate the amount of time the participant was at the park and the period during which the visitor was at the park, which allowed the project team to compare the sounds the participant recorded on the survey to the monitored sounds from the equipment. The survey also inquired about how many visits the participant had made to the park of concern. Information on the number of visits to a park allowed the team to determine whether or not the more one visited a park, the more one was familiar with the non-natural sounds, and the less one was annoyed by the sounds. It was also important to ask what activities the visitors participated in during their visit to the park. When compared to the noise level data, information on types of park visits gave the group a relationship showing how the noise levels and noise sources affected different park activities in different ways. The survey also asked the visitor to rate how enjoyable their visit was on a scale from 1 to 5, 1 being not at all enjoyable and 5 being extremely enjoyable.

After the preliminary questions, it was important to ask which non-natural sounds created the most disturbances to the park. With the data from the personal noise characterization and logging, the project team had expected categories of non-natural sounds and left three blanks for the participant to fill in with the non-natural sounds they expected to hear prior to their visit to the park. To avoid a bias, there was also a choice for no expected non-natural sounds.

Next, the survey questioned what non-natural sounds were heard by the participant and the level of annoyance created by each non-natural sound. This allowed the project team to determine which non-natural sounds were heard the most often, and which created the most annoyance to park visitors. There was also a question asking the level the non-natural sounds interfered with the guests park activities, whether it was not at all, slightly, moderately, very much, or extremely. These questions provided the project team with extremely valuable information on how non-natural sounds affected the experiences of visitors in parks.

Lastly, the survey inquired the level of awareness and concern the participant had for the noise pollution in Puerto Rico. The questions asked how important the participant felt the problem of noise pollution in Puerto Rico was and then asked if the participant had any other comments or suggestions related to the noise pollution. Also, the survey asked the gender and date of birth of the visitors to see how this correlated to noise annoyance. The questionnaire also requested that the visitors provide their zip codes which allowed the project team to determine where the participant lived, whether it was in Puerto Rico or if they were a tourist. The answers to the previously stated questions allowed the team to gain an understanding on how non-natural sound levels affect residents of Puerto Rico compared to tourists.

Data Coding

In order to code the data, the team used tables to log the noise information in, and entered the collected data into Microsoft Excel. In the database containing all of the data from the surveys, a coding system was developed. Each separate surveying and logging station was given a code to separate the different locations. These codes were numerical and are shown on a satellite image of each park in the Results Chapter. In the database, each park was grouped together and each survey from that park was given a number. Also included was the date, weather and location code of each survey. Within the database, the sound sources were grouped into five broader categories; people which includes conversations and children yelling, automobiles such as cars, vans and busses, aircraft like helicopters and airplanes, handheld radios, and maintenance such as vehicles and grounds keeping. A sample of this system is included in the Appendix O.

Results and Analysis

The main goal of this project was to develop an understanding of how non-natural sounds and unwanted noise affect visitor experiences in the parks and natural reserves of Puerto Rico. This section presents the project team's results as well as the analysis of our findings based on the Norsonic-121 sound recordings, the thirty minute sound logs using the Bruel & Kjaer 2232, and the completed visitor surveys. The project team felt that the results would make more sense to the reader if the analysis of the results were presented alongside the findings. The findings from each individual park and reserve are presented first followed by the overall findings based on all four parks and reserves. Table 9 shows the amount of each type of data that was collected in each location.

Table 9 - Acquired Data

Reserve/Forest	Surveys	Observational Logs	Norsonic-121
Piñones	31	4	4 days
El Yunque	98	5	9 days
Humacao	38	6	6 days
Monagas	36	5	2 days

Piñones

In Piñones, two Norsonic-121 monitors were set up in two separate locations along the board walk as shown on Figure 10. Table 6 in the Methodology section details which dates the Norsonic-121 monitors recorded. Each recording period started at 7:00am and ended at 7:00am either twenty-four or forty-eight hours later. Station 1 was located 0.43 mile from the main road, route 187 while Station 2 was much closer to the road being only 0.09 mile away from route 187. The project team decided it would be best to set up the Norsonic-121s a second time because the Norsonic-121 set up at Station 2 did not record as it was supposed to. The Station locations remained exactly the same each time the Norsonic-121s were set up. The first set of Norsonic-

121 readings provided us with a sound level every half hour for the entire forty-eight hour period. Figure 7, below, is a graph below shows typical L_{10}, L_{eq}, and L_{90} sound levels for Piñones based on four twenty-four hour recording periods.

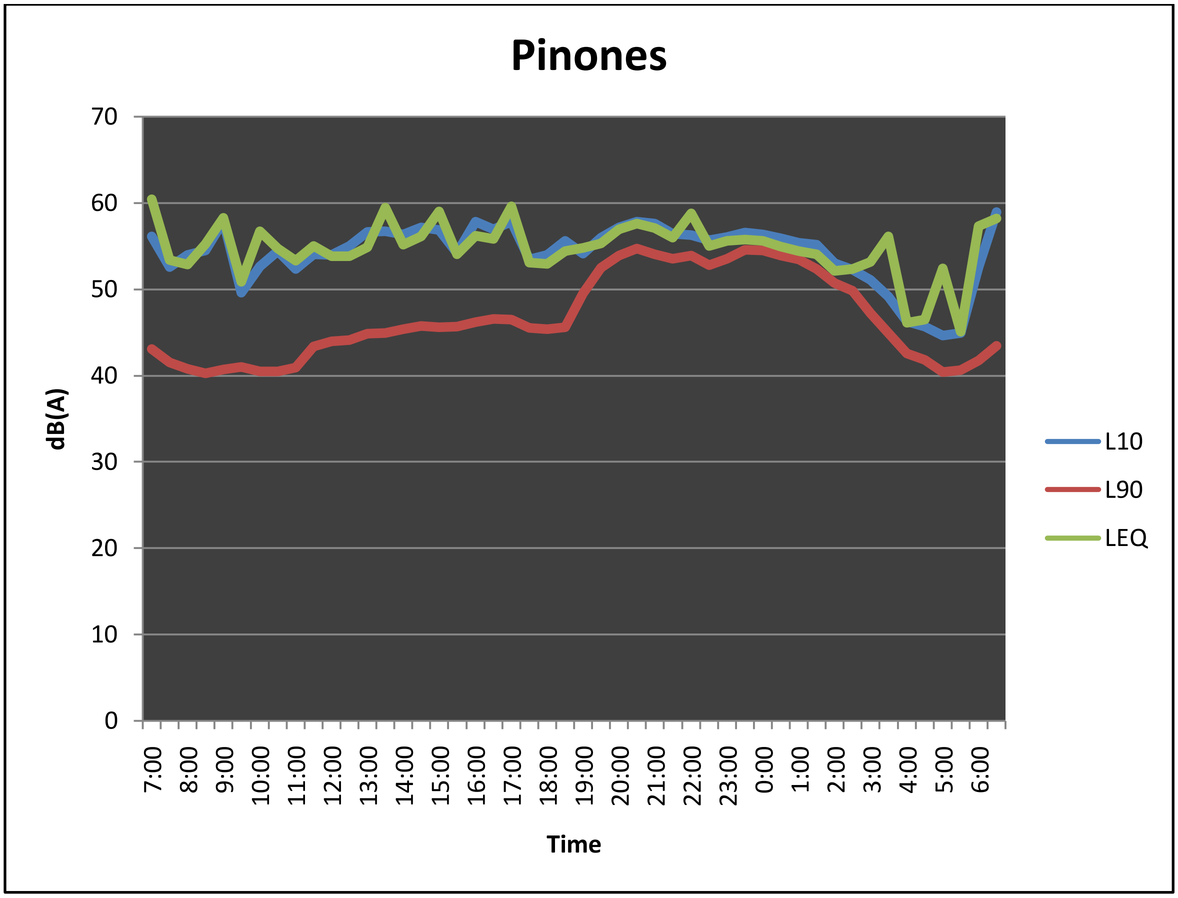


Figure 7 - Leq, L10 and L90 Levels from Piñones

The L_{10}, L_{eq} and L_{90} are the standard indicators used when analyzing decibel data. L_{10} is the decibel level that was exceeded 10% of the time during a given period, and therefore indicates the pattern of the louder noises. L_{90} is the decibel level that was exceeded 90% of the time during a given period and indicates the relative proportion of quieter noises that make up the soundscape. L_{eq} is the equivalent sound level. This means that if you heard the L_{eq} level for the entire time period it would be equivalent to the range of levels in the same time period. In a laboratory situation, with a constant level of noise no measurable variation in decibel levels L_{10},

L_{eq} and L_{90} would become one line. In most real-world settings, the L_{10} and L_{eq} levels would be higher than the L_{90} because there is typically a range of soft and loud noises.

As shown in Figure 7, the L_{10} and L_{eq} levels in Piñones are substantially higher than the L_{90} level between the hours of 7:00am and 7:00pm. The difference between the L_{90} and the L_{10} and L_{eq} are smaller late at night when the lines almost converge. The project team interprets this as loud sound sources that are not constantly present. These sound sources are only heard at certain times, only during the day in this case. In other words, when the lines converge, it means that the sounds heard do not fluctuate much. When the lines separate, it means that the sounds heard do fluctuate a lot, going high and low frequently. Due to the fact that the greatest difference in levels occurs during the daytime hours and the least difference occurs during the night, along with the proximity to the Luis Muñoz Marin International Airport, aircraft are the most likely cause. Aircraft flying over Piñones had a typical decibel range of 56 – 73 dB(A), as recorded in Table 10. However, depending on factors such as how low the aircraft was flying, size of the aircraft, and how close the aircraft was to the receiver, aircraft sounds occasionally fell out of the typical range, registering as low as 54.0 dB(A) and as loud as 82.3 dB(A). The project team logged that there were aircraft overflights every three to five minutes in Piñones. This would greatly increase the L_{10} and L_{eq} levels while not affecting the L_{90} level nearly as much. Piñones is located just about two miles from the airport and, as you can see, the sound levels begin to converge around 8:00 P.M., when air traffic would begin to diminish. They continue to converge throughout the night and by 11:00pm are close to within 5 dB(A). The L_{eq} and L_{10} levels do not lower a significant amount from their daytime levels but the increase in the L_{90} shows that this heightened noise level is most likely due to increased background noise from fauna in the reserve.

The project team completed two observational logs using the Bruel & Kjaer 2236 and two more using the Bruel & Kjaer 2232. The reason behind the change in equipment was that the JCA felt that the Bruel & Kjaer 2236 was not necessary for the observational logs because data did not need to be saved and using the Bruel & Kjaer 2232 would be much easier. The logs were completed near the Norsonic-121 stations also shown on Figure 10. All four half hour logs supported the previous statement that aircraft overflights are the main source of non-natural noise in the reserve, as shown on Figure 8. This is shown by calculating the percentage of sound sources in our logs that were from aircraft compared to the total number of sound sources heard in the logs. Of all the non-natural sounds listed in the logs, 66.7 % of the non-natural sounds were due to aircraft as shown in Figure 8. The observational logs indicated that, on average an airplane, was heard every three to five minutes within a half an hour time period on a given day. Vehicles and people were also observed as frequent noise sources in Piñones. Table 10 shows the typical decibel range that at least 90% of a specific sound source fell into. For example, 90% of vehicle noise fell a range of 50 to 57 dB(A), while 90% of sounds made by people talking, exercising, or yelling registered between 51 and 65 dB(A).

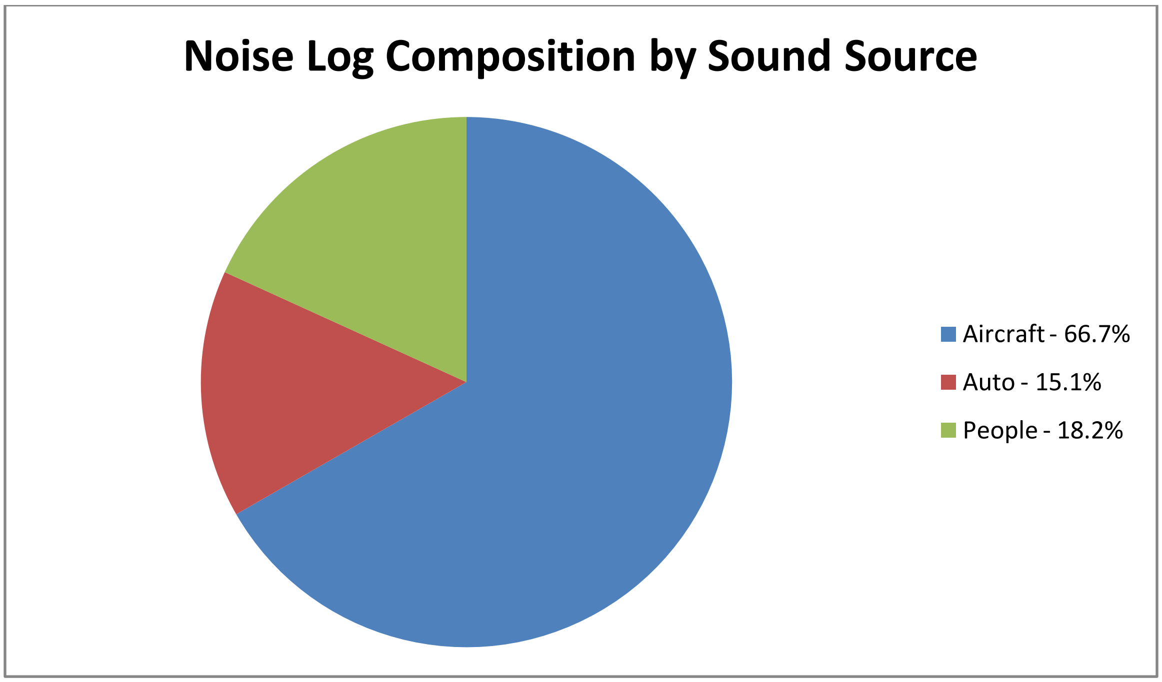


Figure 8 - Noise Log Components by Sound Source in Piñones

Table 10 - Sound Sources in Piñones

Sound Source	Decibel Range [dB(A)]
Environmental Sound Level	42 - 47
Aircraft	56 - 73
Auto	50 - 57
People	51 - 65

Originally, the team planned on collecting visitor surveys on the boardwalk where sound data was collected, but during site visits it became clear that very few visitors on the boardwalk were willing to complete surveys. Consequently, the noise monitors were set up along the boardwalk, as indicated in Figure 10, but surveys had to be conducted at the entrance of the boardwalk, next to the parking lot. Thirty-one surveys were completed in Piñones and Figure 9 shows what noise sources visitors mentioned and how annoying they felt each specific noise source was.

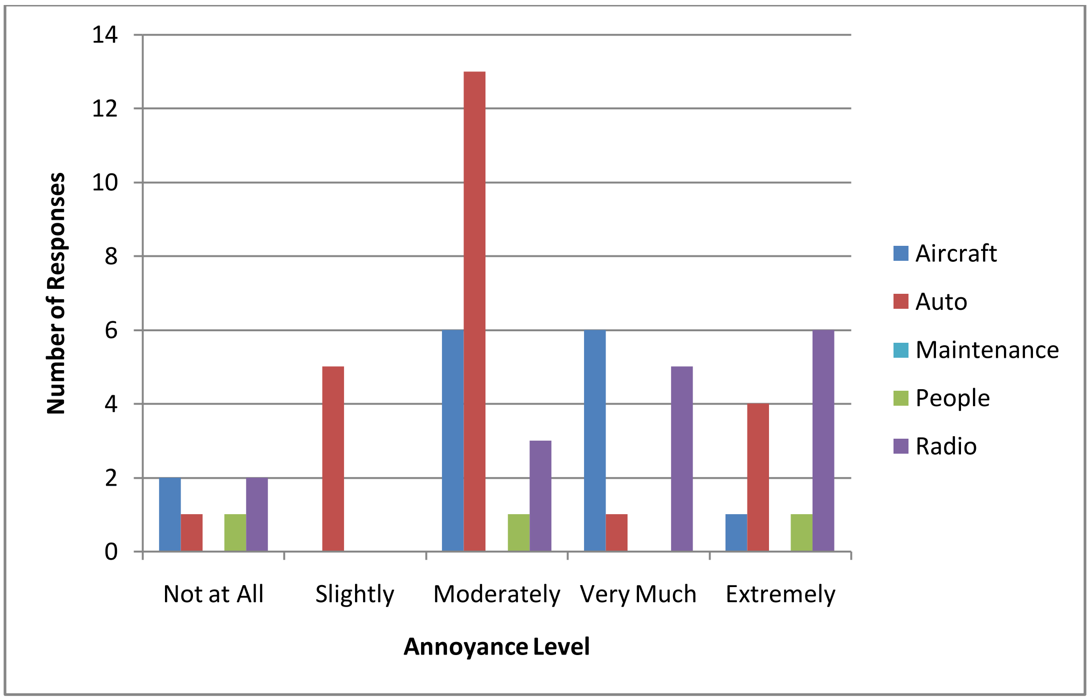


Figure 9 - Histogram of Sound Source Annoyance in Pinones (n = 31)

Figure 9 shows that Piñones has three main noise sources that cause annoyance; aircraft, autos, and radios. Just over 45 % of Piñones visitors questioned found radios bothersome, several respondents indicated that radios were very or extremely annoying resulting in an average annoyance rating of 4.21 on a 1 to 5 scale where 1 is not at all annoying and 5 is extremely annoying. (Note that the average level of annoyance was calculated by omitting those respondents giving a score of 1). The most frequently noted source of annoyance by visitors was automobiles with over 74 % of visitors mentioning vehicles as an annoyance of either 2 or higher on the 1 to 5 scale. The average annoyance level of autos was a 3.17 on the same 1 to 5 scale.

The final major cause of annoyance was aircraft, which had an average annoyance level of 3.62 out of a possible 5 and almost 42% of visitors noted aircraft as annoying. These numbers are extremely high when compared with the other parks that the project team analyzed. No other location had three sound sources about which more than 10% of visitors complained. In addition, Piñones has four different sound sources that cause annoyance levels of either a 3, 4, or 5 on the 1 to 5 scale, while no other park has more than two such sound sources.

Figure 10 shows a satellite image of Piñones, taken from Google Earth (2008). The thumbtacks represent locations that were either Norsonic-121 recording stations, locations where observational logs were completed, areas where visitors were surveyed, or a combination of the three.

Figure 10 - Piñones Natural Reserve

El Yunque

Four norsonic-121 monitors were set up in El Yunque recording 48 hours of sound levels starting again at 7:00am on the dates listed on Table 6 in the methodology chapter and ending at 7:00am. The locations of the Norsonic-121 monitors are shown on the map of El Yunque on Figure 14. Station 1, 2, and 3 were located just a few feet from the road while Station 4 was located at a bird sanctuary 0.11 mile from the main road. Two more Norsonic-121s were set up again at Stations 1 and 2 on the dates indicated on Table 6. It is important to note that traffic noise was inevitably a dominant noise recorded by the Norsonic-121 monitors due to their proximity to route 191. This site was chosen as appropriate for monitoring because traffic noise is a part of the normal daily background noise in the visitor areas in El Yunque. The graph of El Yunque's natural soundscape was made by taking all the data from nine 24-periods and averaging them into one graph, creating a typical sound profile. Figure 11 shows the L_{10}, L_{90}, and L_{eq} for El Yunque.

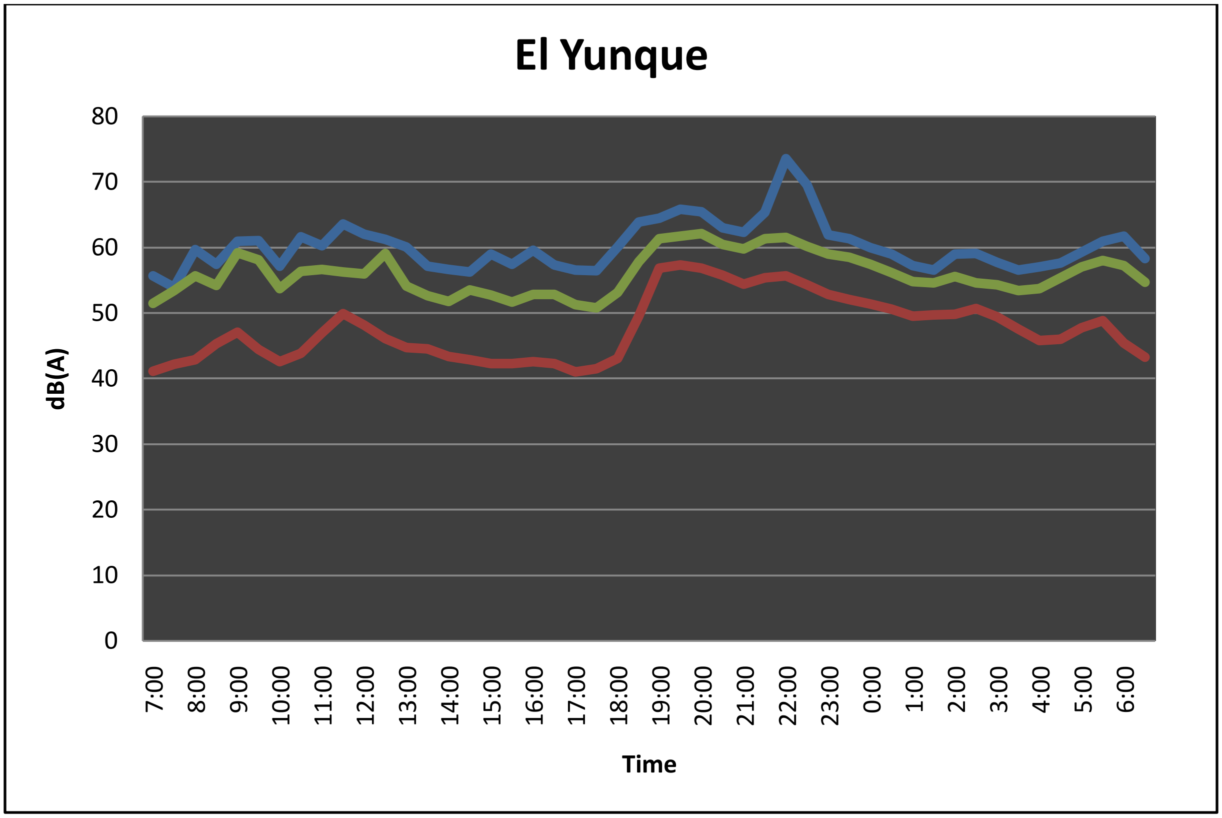


Figure 11 - Leq, L10 and L90 Levels from El Yunque

From the graph it is evident that the general background noise level is lower during the daytime hours, increasing at around 6:00pm and falling off again throughout the early morning hours. The project team believes that this pattern is a result of noises made by fauna, such as frogs, that tend to vocalize during the nighttime hours.

Five half-hour observational logs were taken using the Bruel & Kjaer 2232. The environmental noise level was between 41 and 51 dB(A). Four logs were taken just off to the side of paths and three of those four logs showed that conversations among visitors was the dominant non-natural noise, making up 72.1% of the sound sources recorded in the noise logs as shown in Figure 12. The percentages for this graph were calculated by totaling the number of sounds recorded in the observational logs at each given park. The total number of recorded airplane overflights was then divided into the total number of recorded sounds to receive a percentage of how frequently aircrafts were heard in comparison to the other recorded noises. This process was done in each park to get percentages of aircraft, auto, people, and maintenance noise. Just over 90% of the sound levels caused by people registered between 48 and 70 dB(A) (Table 11). The range is rather broad because the acoustics produced by people varied from mild conversations to yelling and many times involved small children. The fourth log completed mid-trail also showed that conversations were a frequent source of non-natural noise, but the loudest source of non-natural noise was a park services' vehicle driving back and forth doing trail maintenance with all of the noise levels caused by park services' vehicle falling between 73 and 78 dB(A). Table 11 shows the decibel ranges of each sound source. The fifth log was taken at a trail head next to a parking lot where cars were the main source of noise. At times, nearby cars and buses generated noise twenty to thirty decibels higher than the environmental background noise. While vehicle sounds normally fell between 54 to 72 dB(A), occasionally the sound level would reach as high as 83 dB(A) due to car horns and loud acceleration occurring in close proximity to the Bruel & Kjaer 2232. The decibel ranges in El Yunque are somewhat different than the ranges of sound found in Piñones due to the proximity of the sound sources to the park. For example, in El Yunque, a road runs right next to the trail heads, while in Piñones the road is farther from the trails.

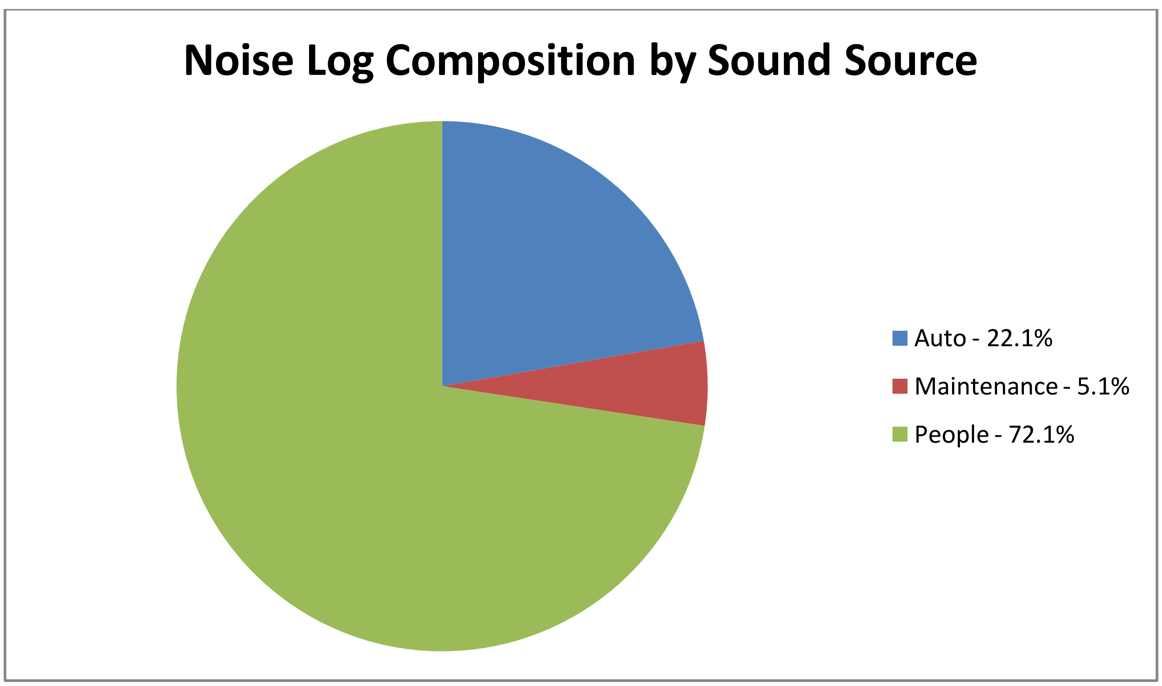


Figure 12 - Noise Log Components by Sound Source in El Yunque

Table 11 - Sound Sources from El Yunque

Sound Source	Decibel Range [dB(A)]
Environmental Sound Level	41 - 51
Auto	54 - 72
Maintenance	73 - 78
People	48 - 70

Of the visitors approached, there were a total of 98 visitor surveys completed with only five refusals to participate in El Yunque. The surveys completed indicated that noise from automobiles and other visitors are the most commonly mentioned annoyances in El Yunque (Figure 13). Of the visitors surveyed, 42.86 percent noted that autos interfered with their enjoyment of the park. As indicated in Figure 13, most of these people were only slightly or moderately annoyed by the noise of automobiles, but a substantial number were very or extremely annoyed. The average annoyance level was 2.81 on a scale of 1 to 5, 1 being not at all annoyed and 5 being extremely annoyed. This finding is not at all surprising considering that all of the trail heads are located in either a parking lot or on the side of the main road that runs up the mountain.

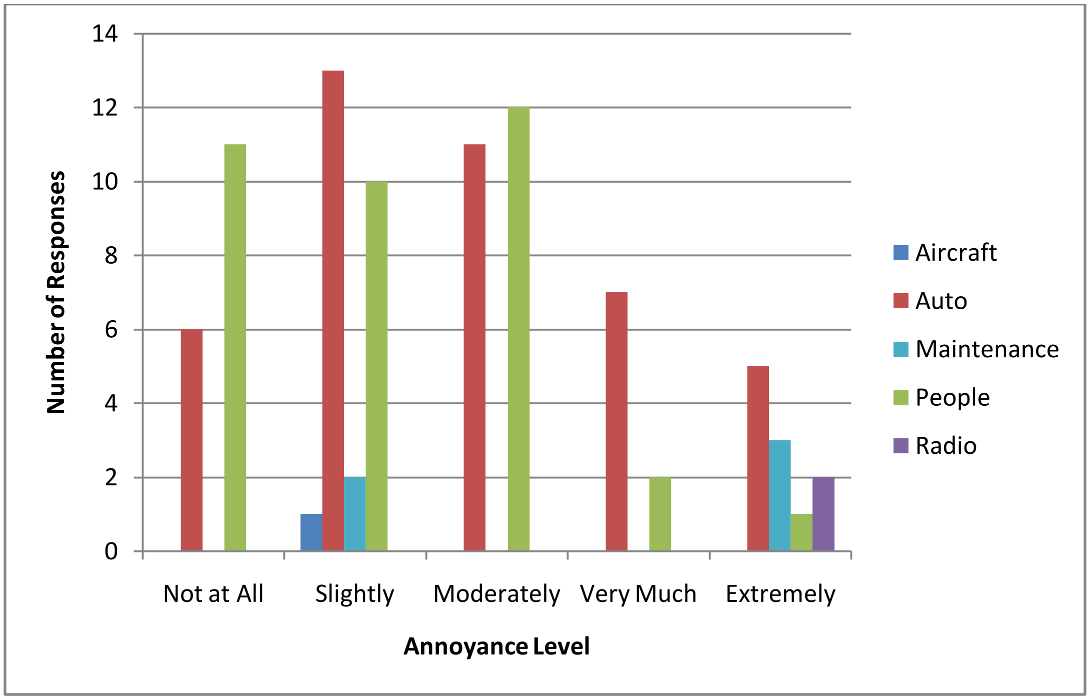


Figure 13 - Histogram of Sound Source Annoyance Levels in El Yunque (n=98)

Twenty five percent of respondents complained about the noise people made talking, yelling, or screaming. Figure 13 indicates that most of these respondents were only slightly or moderately annoyed, resulting in an average annoyance level of 2.22 out of 5. On April 2nd, 2008 there was a park maintenance vehicle going back and forth at the La Mina trail head and forty percent of visitors surveyed in that area on the 2nd of April noted noise from a maintenance vehicle as their main complaint. As indicated in Table 11, noise from the maintenance vehicle exceeded 73 dB(A). Excluding these 28 respondents, no other visitors surveyed mentioned noise from maintenance work as an issue.

Figure 14 is a map a satellite map of El Yunque taken from Google Earth (2008). Each thumb tack represents an area where either the Norsonic-121's recorded, observational logs were taken, visitors were surveyed, or a combination of the three.

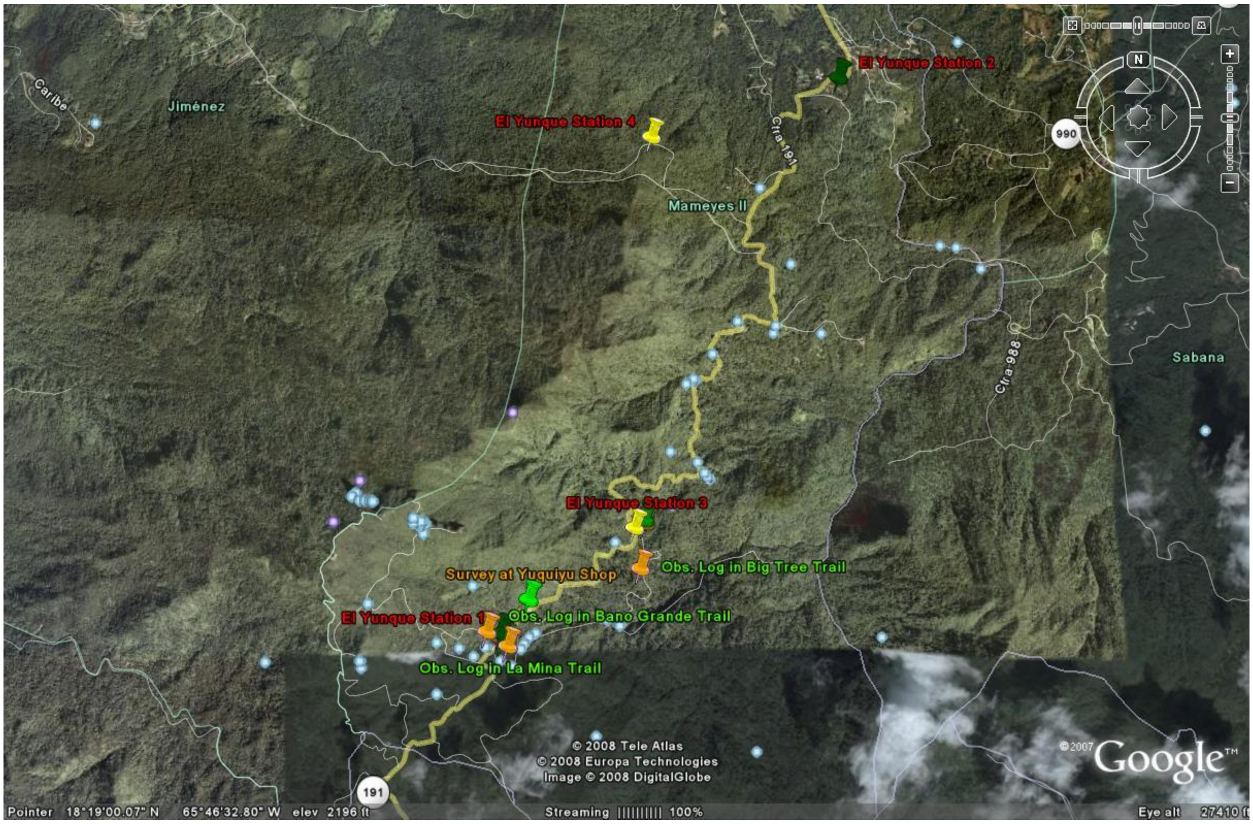


Figure 14 - Monitoring and Surveying Locations in El Yunque National Forest

Humacao

The project team set up three Norsonic-121 monitors in three locations in Humacao as shown on the Figure 18. Station 1 was located just 0.07 miles from main road, Station 2 0.15 miles, and Station 3 was 0.45 miles away from the road. The monitors recorded 48 hours worth of sound data starting at 7:00am on the dates indicated on Table 6 in the Methodology chapter, and ending again at 7:00am. Figure 15 is a graph of the average L_{10}, L_{eq}, and L_{90} levels of Humacao.

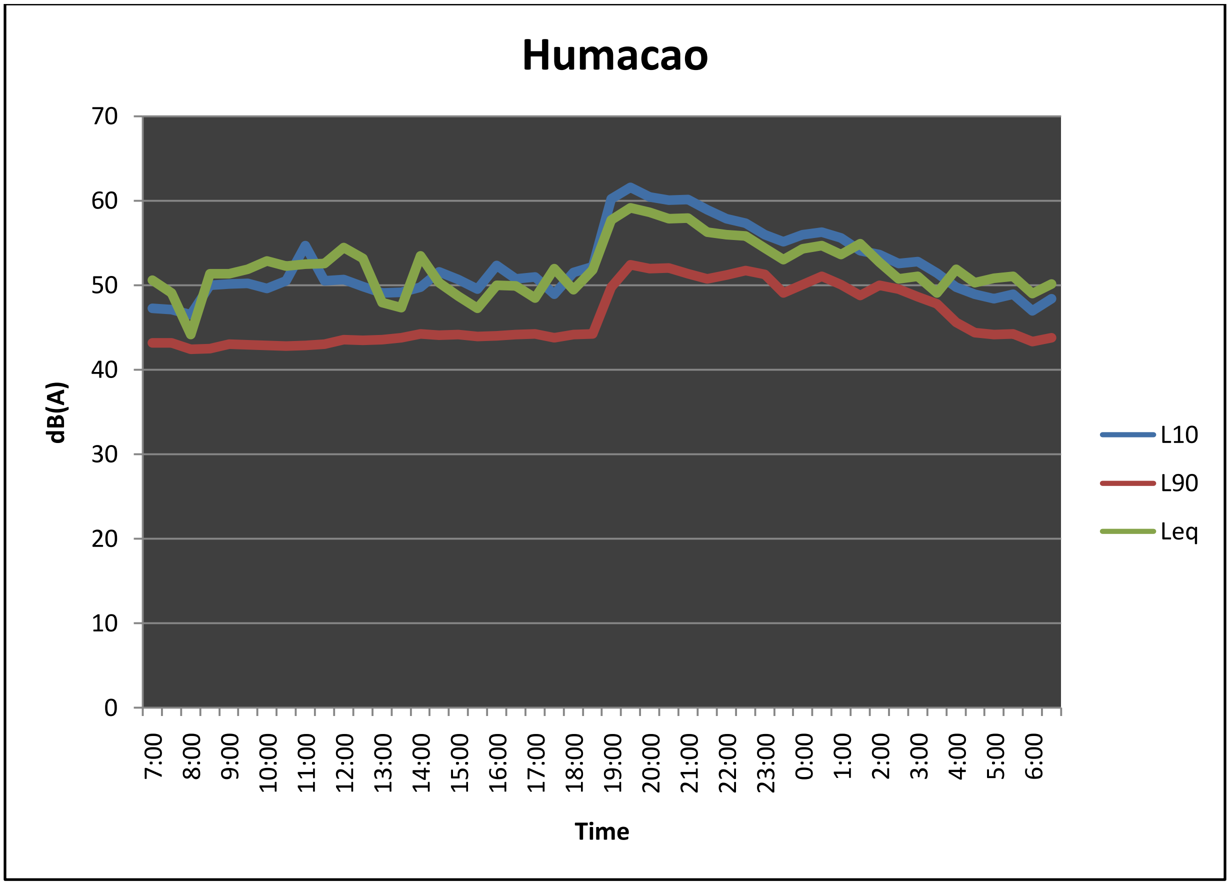


Figure 15 - Leq, L10 and L90 Levels from Humacao

This graph shows the typical sound level in any given twenty-four hour period. It was made using data from six twenty-four hour periods (two twenty-four hour periods from each of the three stations). During daylight hours, the background noise level (L_{90}) is right around 43 dB(A). From 6:30 pm to 7:30 pm, there is a dramatic increase in the sound levels, with the L_{90} jumping up to 52 dB(A), and then gradually decreasing back down to 43 dB(A). This pattern is very similar to the pattern in El Yunque and again probably reflects the nocturnal fauna sounds. The difference between the L_{10} and the L_{90} is a little smaller, about 5 dB(A) lower, in Humacao than it is in El Yunque. This is likely because El Yunque has a much more diverse soundscape due to the vast fauna and frequent rainfall which would cause many different sound sources resulting in a much larger range of sounds compared to Humacao. The wide sound range would cause a larger difference in the L_{10} and L_{90} levels.

The team completed six observational logs in Humacao in six locations. The observational logs revealed that automobiles, aircraft, and people generate the most non-natural noise in Humacao as shown in Figure 16. The graph in Figure 16 shows that about 65 % of the non-natural sounds heard in the logs were caused by people, making up the majority of the sounds heard. Table 12 shows the sound level range of the at least 90% of each specific sound source fell into in Humacao. The background noise was normally right around 44 dB(A) when no wind was present. All aircraft sounds fell between 50 and 65 dB(A). Not surprisingly, this range is a lower than the range used in Piñones, where planes are landing or taking off at the nearby San Juan International Airport. There are no airports near Humacao, and the aircraft recorded are at much higher altitudes than they are near Piñones. Sounds from people talking or yelling ranged from 50 dB(A) to 61 dB(A). The majority of the sounds caused by people were recreational fishermen either talking or moving around their equipment. Due to the proximity to Route 3, however, traffic was an almost constant identifiable source. Unfortunately, the Bruel & Kjaer 2232 could not always separate the traffic sounds from the background environmental noise unless the car sounds, such as car horns and screeching tires, were especially loud. Sounds such as these from the highway or parking lot area typically fell between 50 dB(A) and 65 dB(A). Depending on distance, however, the team did record vehicle noises as high as 83.7 dB(A), especially if the vehicle drove into the reserve on the trails. This happened on one occasion while the team was completing a log. A DRNA truck was driving through the trails, causing elevated sound readings.

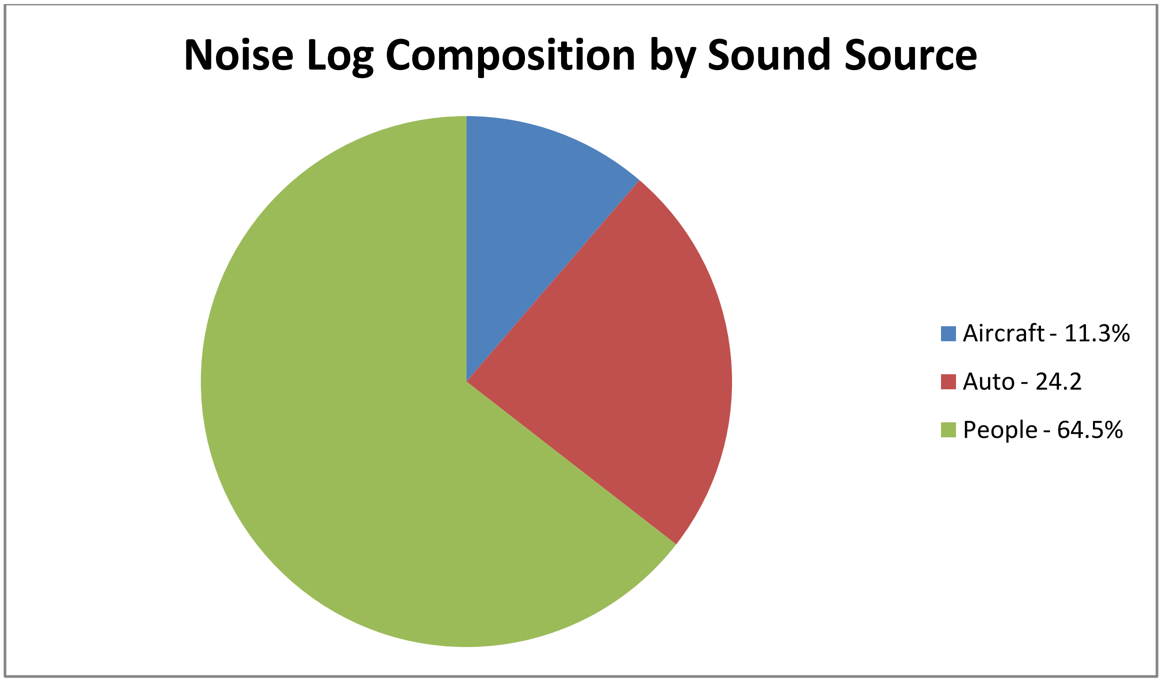


Figure 16 - Noise Log Components by Sound Source in Humacao

Table 12 - Sound Sources from Humacao

Sound Source	Decibel Range [dB(A)]
Environmental Sound Level	40 - 50
Aircraft	50 - 65
Autos	50 - 65
People	50 - 61

In Humacao, the team asked 40 visitors to participate in the survey; 2 people refused and 38 completed surveys. As in El Yunque, respondents complained most about the noise of automobiles and other visitors. Thirty one percent of respondents indicated that they were bothered by vehicle noise, as shown on Figure 17.

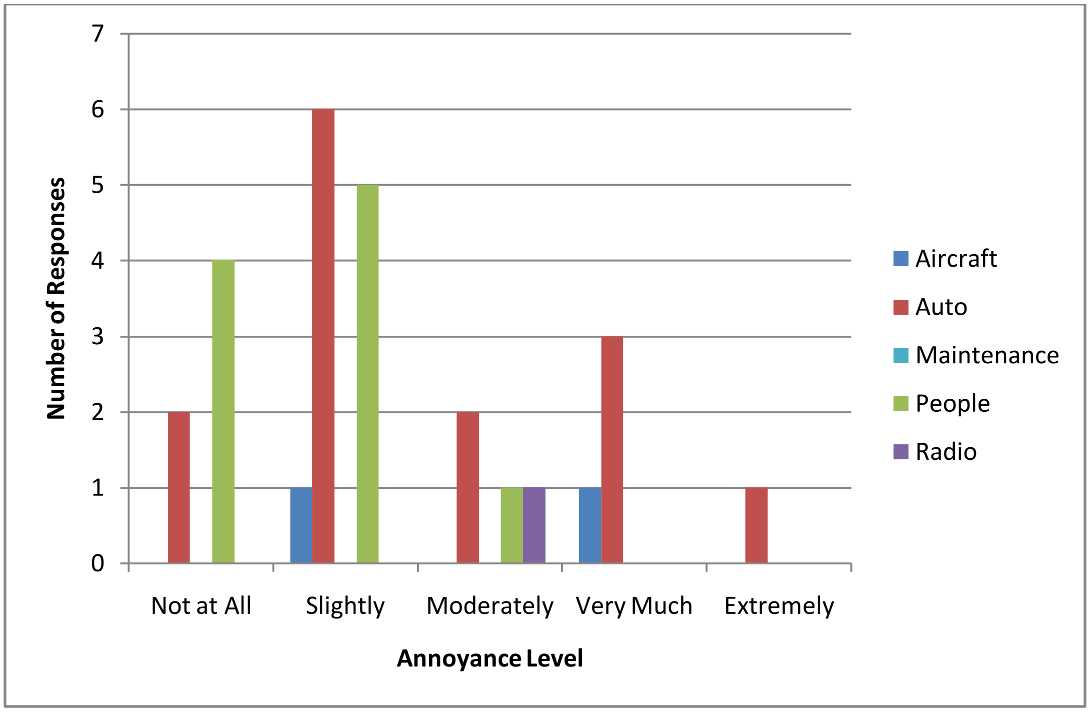
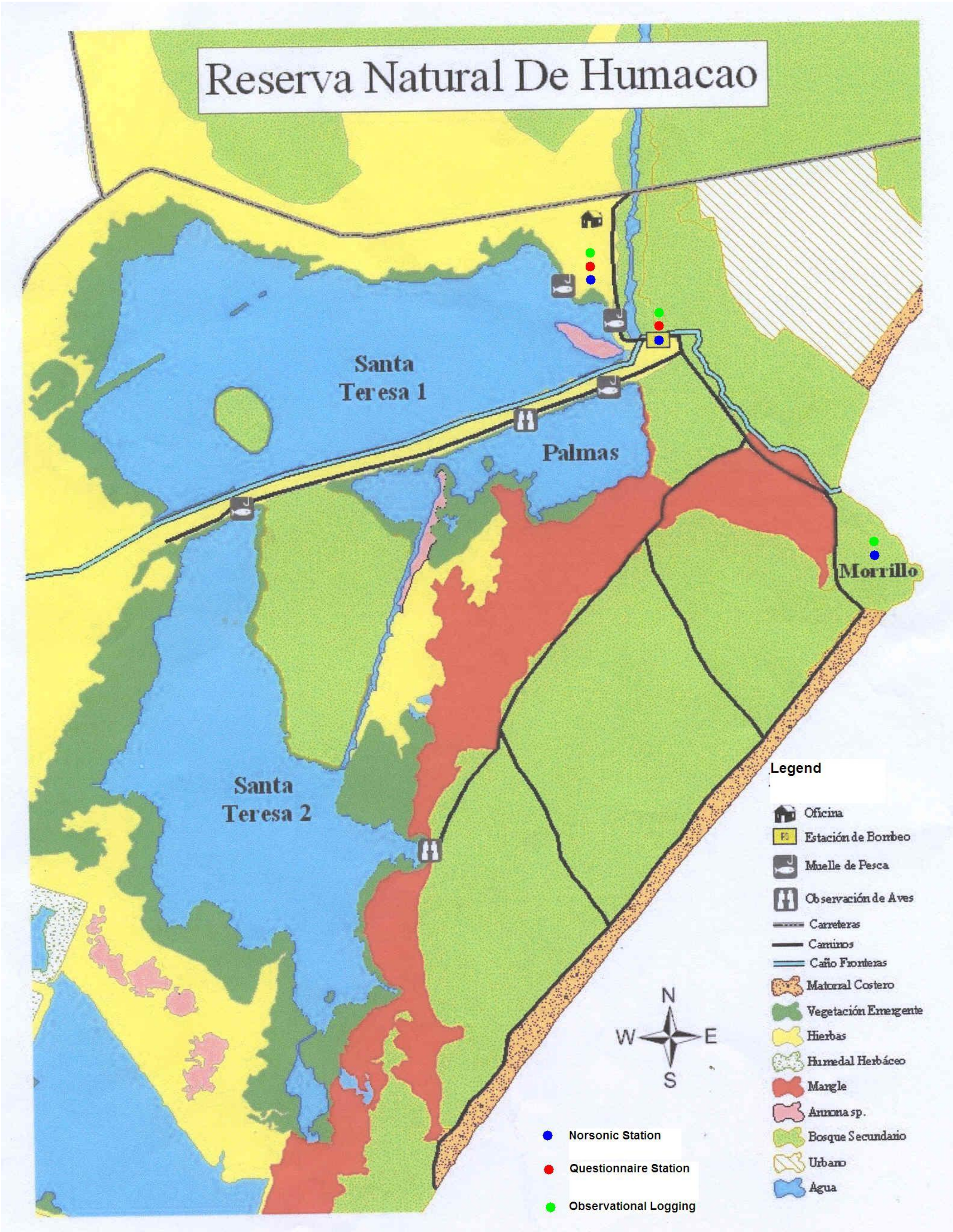


Figure 17 - Histogram of Sound Source Annoyance Levels in Humacao (n=38)

Figure 17 shows that automobiles were the dominant source of annoying noise at Humacao, although most respondents were only slightly or moderately annoyed resulting in an average level of annoyance of 2.92 on a scale of 1 to 5. Several people expressed a slight annoyance about noise made by others at the park, although several others said they were not at all annoyed by such noise.

Figure 18 below is a trail map of Humacao. The blue dots indicate Norsonic-121 recording stations, red dots represent locations where visitor surveys were administered, and green dots indicate locations where observational log were completed.

Figure 18 - Humacao Natural Reserve



Monagas

The project team set up two Norsonic-121's in two different locations, recording for twenty-four hours each. Station 1 and 2 are shown on a map of Monagas on Figure 22. The monitors started recording at 7:00 am and ended at 7:00 pm on the dates indicated on Table 6 in the Methodology chapter. Figure 19, shown below, is a graph of a typical sound profile of Monagas for a twenty-four hour period. The graph was made by averaging the sound levels recorded by the Norsonic-121s.

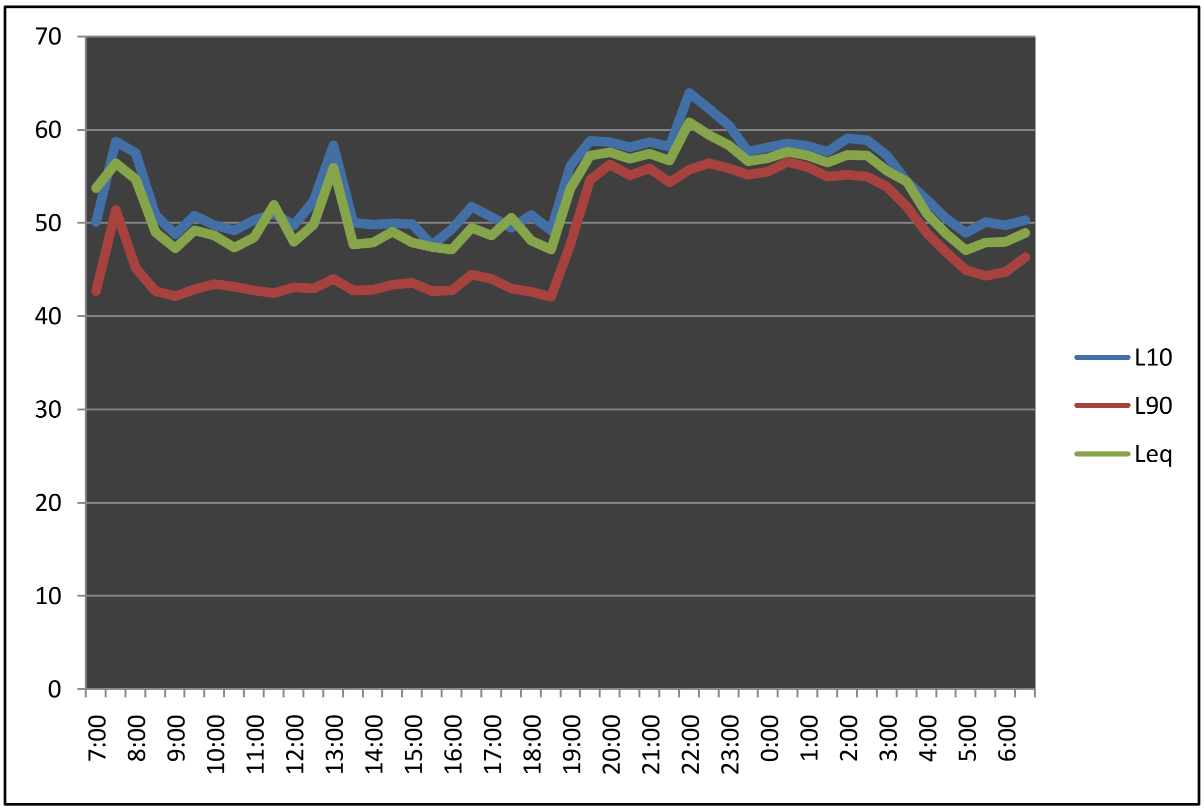


Figure 19 - Leq, L10 and L90 Levels from Monagas

Figure 19 shows that the difference between the L_{90} is and the L_{10} is much larger during the daytime hours. Around 6:30pm, the L_{90} starts to converge with the L_{10} and the L_{eq}. What this means is that during the day, there is an increased amount of loud sounds that are not a part of the normal background sounds. At the same time that the lines converge, the overall sound level increases dramatically. The increase in the L_{90} means that the background noise gets louder, as at least 90% of the sound levels increase. This is, again, likely due to increased sounds from the nocturnal fauna living in Monagas.

Six observational noise logs were completed in Monagas using the Bruel & Kjaer 2232 monitor. Data from one of the first two logs recorded on March 29th, 2008 had to be discarded because one of the Bruel & Kjaer monitors malfunctioned due to a microphone obstruction. This left the project team with five usable noise logs. Table 13 shows the sound ranges that 90% of each specific sound source fell into in Monagas. All aircraft sounds registered sound levels between 52 dB(A) and 60 dB(A). Like Humacao, Monagas is not as close to the major airport as Piñones is, hence the lower sound ranges. On the lower recreational area of Monagas, there is a road for visitors to drive on. Vehicle sounds in this area were louder, but less frequent, while up by the observational tower (Station 2) there was not a road running through, but there was highway in sight. The vehicle sounds heard up by the tower are slightly quieter yet constant traffic sounds blended in with the background noise and any screeching brakes or honking from the highway on top of that. Automobile sounds made up the biggest percentage of sound sources recorded in the sound logs making up 44.2% of the logs (see Figure 20).

Table 13 - Sound Sources from Monagas

Sound Source	Decibel Range [dB(A)]
Environmental Noise Level	46 - 50
Aircraft	52 - 60
Auto	51 - 60
Maintenance	73 - 78
People	51 - 70

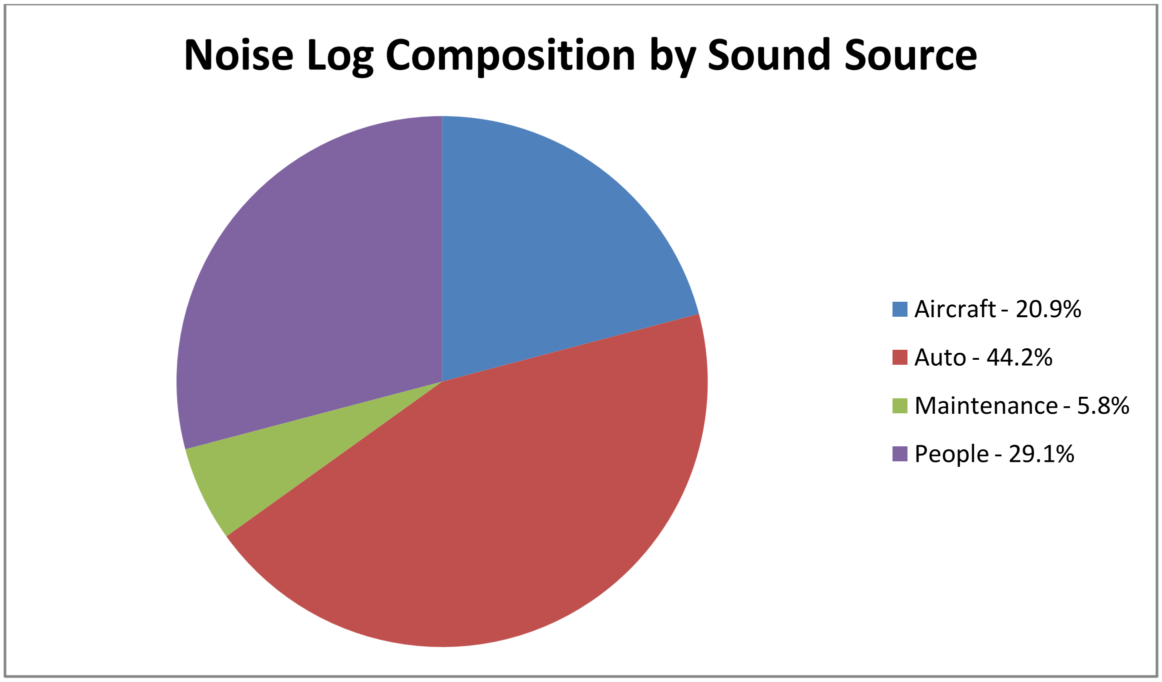


Figure 20 - Noise Log Components by Sound Source in Monagas

Monagas yielded 36 completed visitor surveys with just three rejections. Almost half of the visitors the team questioned listed autos as one of their main noise complaints. The average annoyance level was a 2.87 of 5, 5 being extremely annoying and 1 being not at all annoying. The second most commonly mentioned noise problem was with noise made by people. The average level of interference was 2.5 out of 5 and mentioned by 5.56 % of those surveyed. Another noise source mentioned in the surveys was aircraft, with an annoyance level of 2.5. Radios were mentioned by 2.78% of visitors surveyed, but because they indicated an annoyance level of 1, not at all annoyed, it was not included when figuring out the average annoyance level.

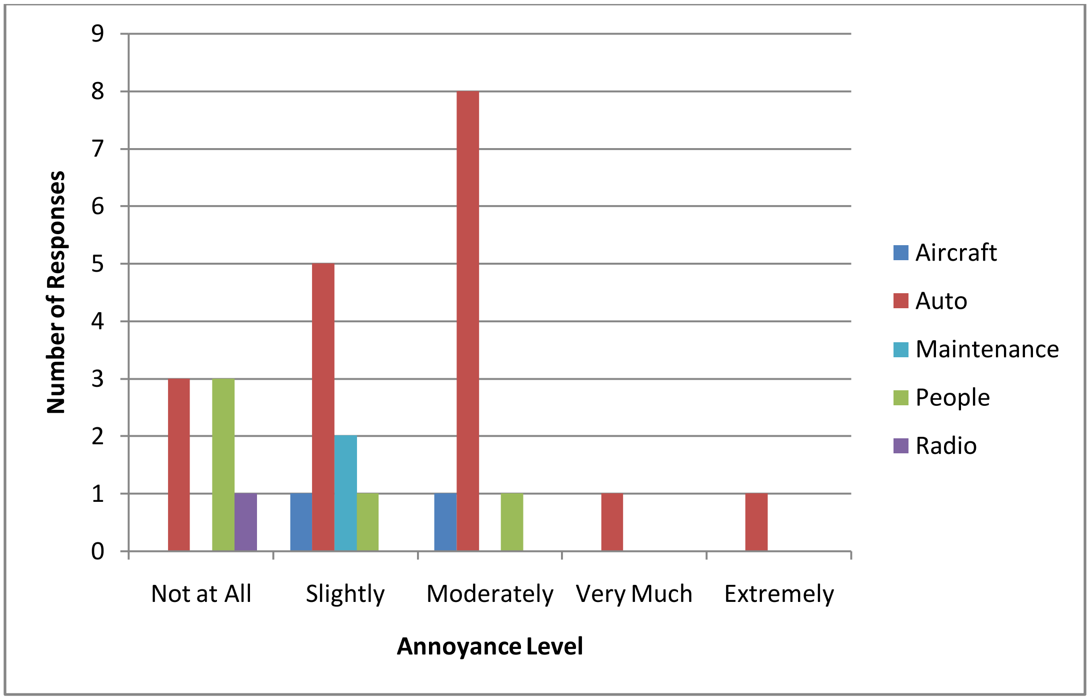


Figure 21 - Annoyance Level of Sound Sources in Monagas (n=36)

Figure 21 indicates that automobiles were the most annoying source of noise at Monagas, although most visitors were only slightly or moderately annoyed and a small number indicated that they heard the noise but were not at all annoyed. Given the small number of responses in the park, it would be helpful to conduct further research to see if these same patterns are affirmed in a larger sample.

Figure 22 shows a trail map of Monagas. The blue dots represent Norsonic-121 recording stations, red dots are places where observational logs were taken, and the green dots are place where visitor surveys were administered.

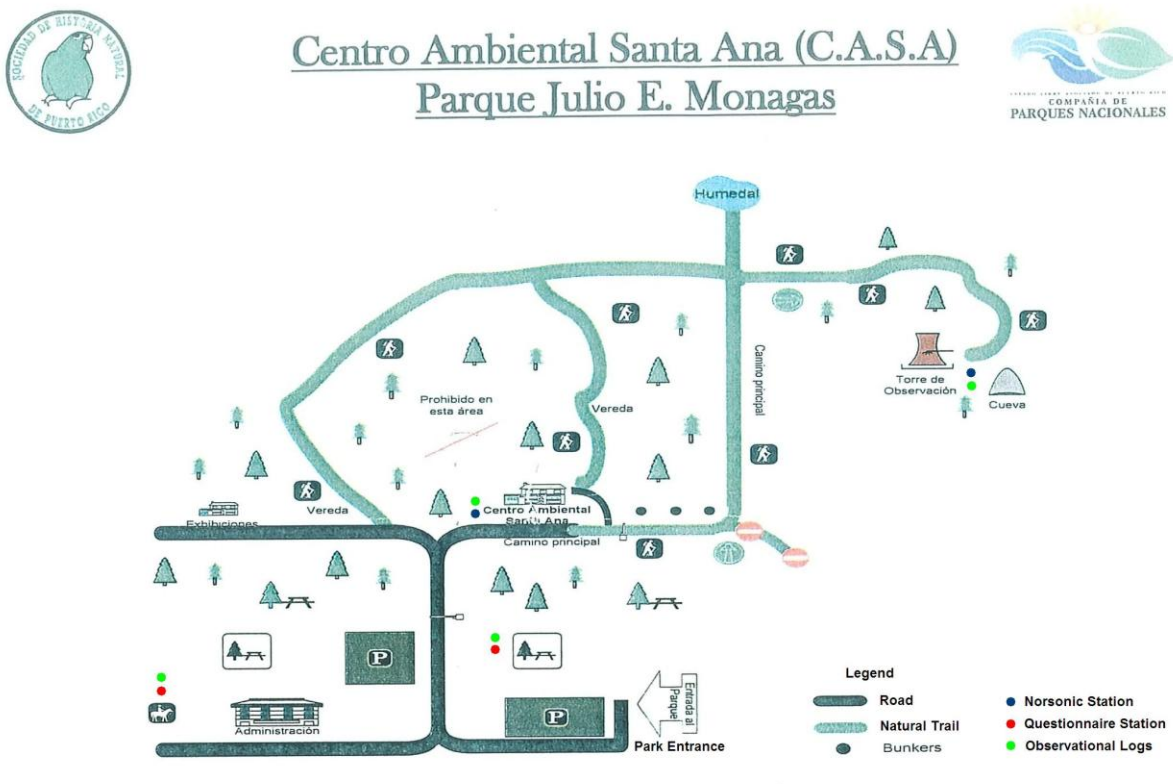


Figure 22 - Map of Monagas

Overall Results

The 30-minute sound logs were used to indicate what sounds sources interfere with the natural sound level of each park. Non-natural sound sources common to all four reserves included autos and people. Table 14, shown below, illustrates the various noise sources and decibel ranges indentified in each location using the observational logs. At least 90% of the sound levels emitted from each source listed fell into the decibel range specified. The categories included aircraft, auto, maintenance, and people. The decibel ranges fluctuate greatly because in such categories as people, the noise source varies from quiet conversation to loud screaming children. The auto category is also contrasting from cars to trucks and includes muffler noise as well as horns. The closer the sound source was to the receiver, the louder the decibel reading. Aircraft is a large range as well, especially when talking about all of the location put together. This is because aircraft are louder in Piñones because the airplanes fly at a lower altitude either landing into or taking off from the airport about 2 miles away from the reserve. As mentioned earlier, in Humacao and Monagas, any aircraft flying over, is doing so at a higher altitude, i.e. further away from the receiver, therefore they do not sound nearly as loud.

Table 14 - Decibel Ranges of Common Noise Sources

SOUND SOURCE	RESERVE/FOREST	DECIBEL RANGE
Background Noise	Piñones	42 - 47
	El Yunque	41 - 51
	Humacao	40 – 50
	Monagas	46 – 50
Aircraft	Piñones	56 - 73
	El Yunque	N/A
	Humacao	50 - 65
	Monagas	52 - 60
Autos	Piñones	50 - 57
	El Yunque	54 - 72
	Humacao	50 - 65
	Monagas	51 - 60
Maintenance	Piñones	N/A
	El Yunque	73 - 78
	Humacao	N/A
	Monagas	73 - 78
People	Piñones	51 - 65
	El Yunque	48 - 70
	Humacao	50 - 61
	Monagas	51 - 71

The observational logs indicated that the four most common, non-natural sources of sound in the reserves were from, aircraft, automobiles, maintenance crews, and people. Figure 23 clearly indicates which sound sources dominated in each park. In Piñones, noise emitted by aircraft overflights made up the majority, about 65 %, of non-natural sounds recorded in the noise logs while aircraft noise was not noted noted in El Yunque. Sounds made by people, ranging from soft conversations to yelling, made up 73 % and 64 % of noises recorder in Humacao and El Yunque. Monagas had some aircraft noise (22%), but was dominated by noise from automobiles (45%) and people (28%).

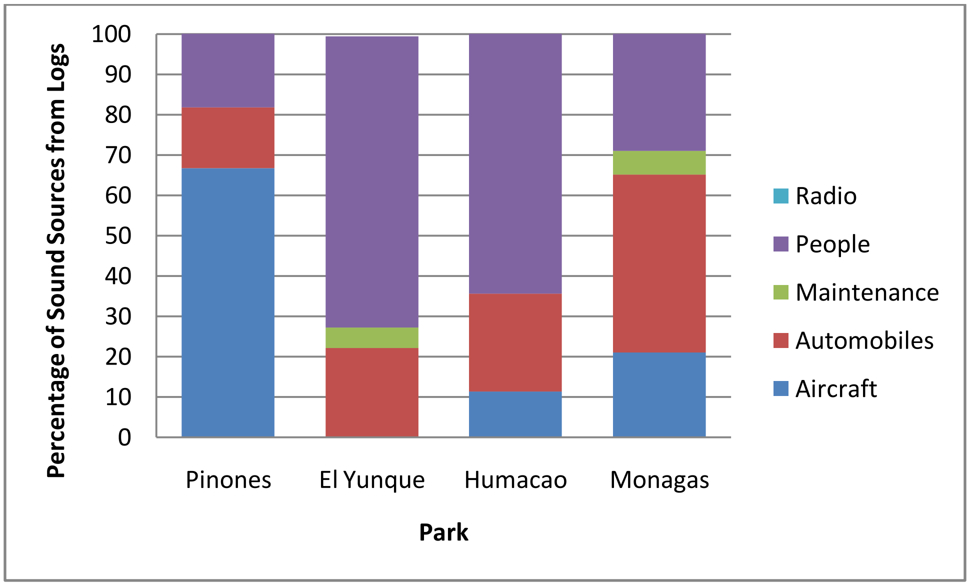


Figure 23 - Percentage of Sound Sources from Observational Logs by Park

The project group gathered and analyzed questionnaires from the previously mentioned parks and reserves in Puerto Rico. The following tables and graphs of results summarize some of the principal findings of interest. Figure 24 shows that the average level of visitor enjoyment varied little among the parks ranging from a high of 4.55 in Humacao to a low of 4.16 in Piñones, based on a scale of 1-to-5 with 1 being “not at all enjoyable” and 5 being “extremely enjoyable.” As the graph in Figure 24 illustrates, average level of visitor enjoyment in each park is very high, despite the noise complaints listed in the visitor surveys.

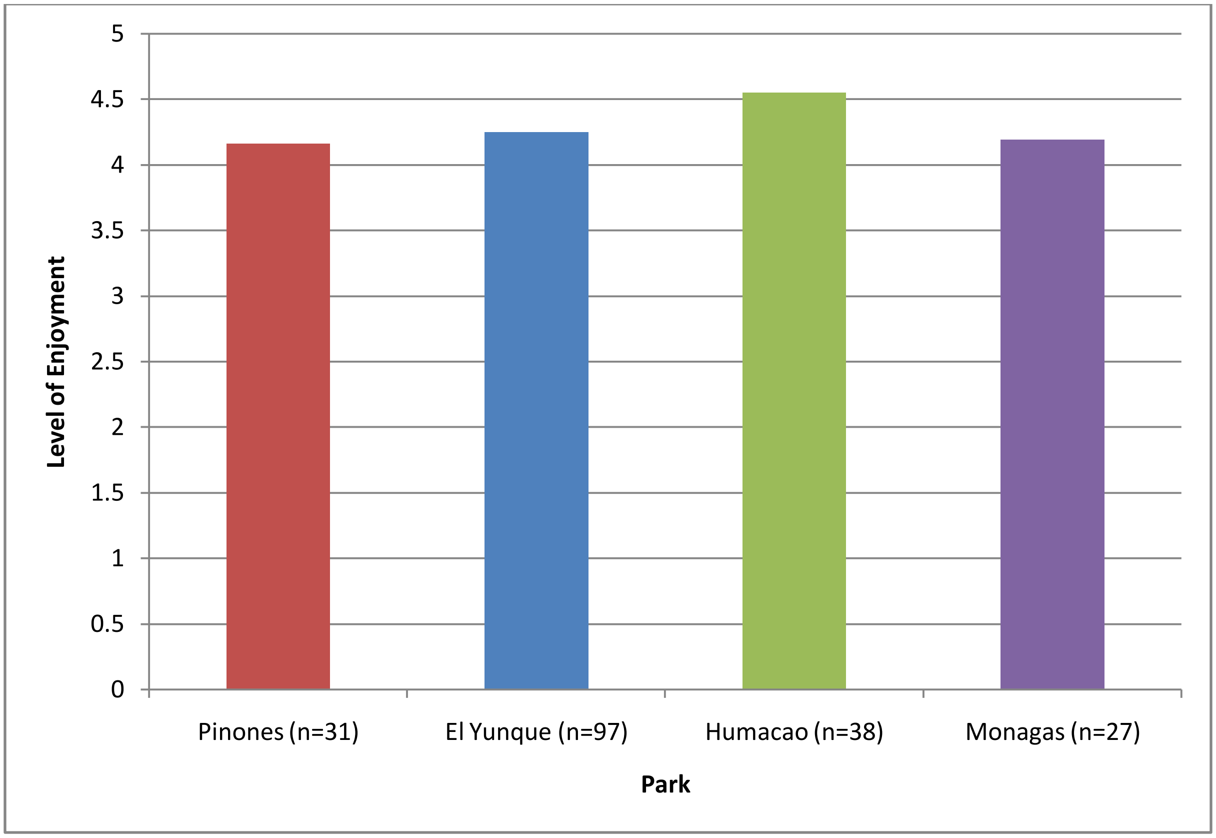


Figure 24 - Enjoyment Levels in Selected Parks

The questionnaire asked participants to indicate how important viewing the natural scenery, hiking or exercising, and enjoying the natural quiet was in their decision to visit the park based on a five point scale where 1 is "not at all important" and 5 is "extremely important." The next set of graphs shows the differences of the importance of the mentioned park activities and the interference of noise within these activities. Figure 25 shows a bar graph displaying the average importance levels reported in the different parks.

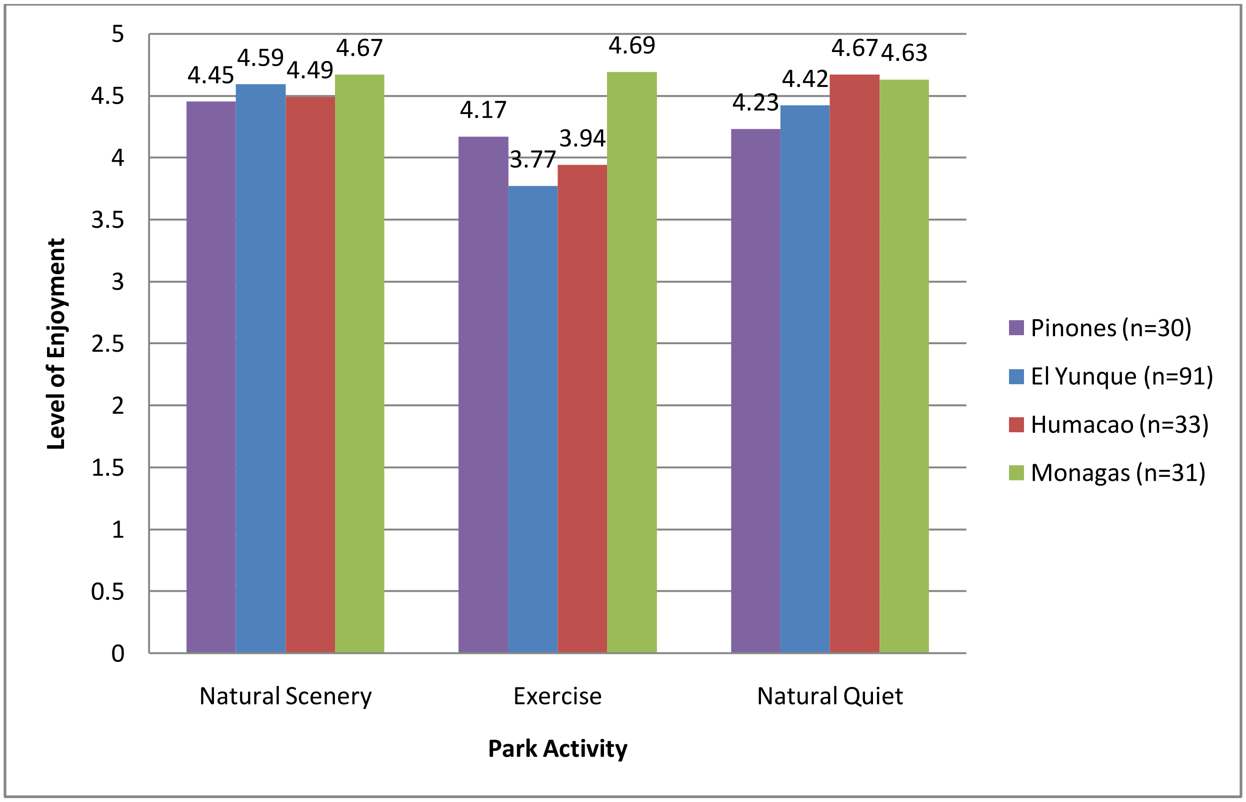


Figure 25 - Importance of Park Activities

From the results, it is evident that overall viewing the natural scenery and experiencing the natural quiet are very important for visitors, and respondent ratings on these items vary little among parks. The average importance of viewing the natural scenery ranged from 4.45 in Piñones to 4.67 in Monagas, while the average importance for experiencing the natural quiet ranged from 4.23 in Piñones to 4.67 in Humacao. Generally, respondents rated exercise as less important, except those respondents in Monagas.

The questionnaire asked what non-natural sounds the park visitor expected to hear prior to their visit to the park. The answers were separated by the project group into five different categories; aircraft, automobiles, maintenance, people, and radios. Shown below in Figure 26 are the percentages of visitors in each park who responded on their questionnaire that they expected to hear any of the categorized noises.

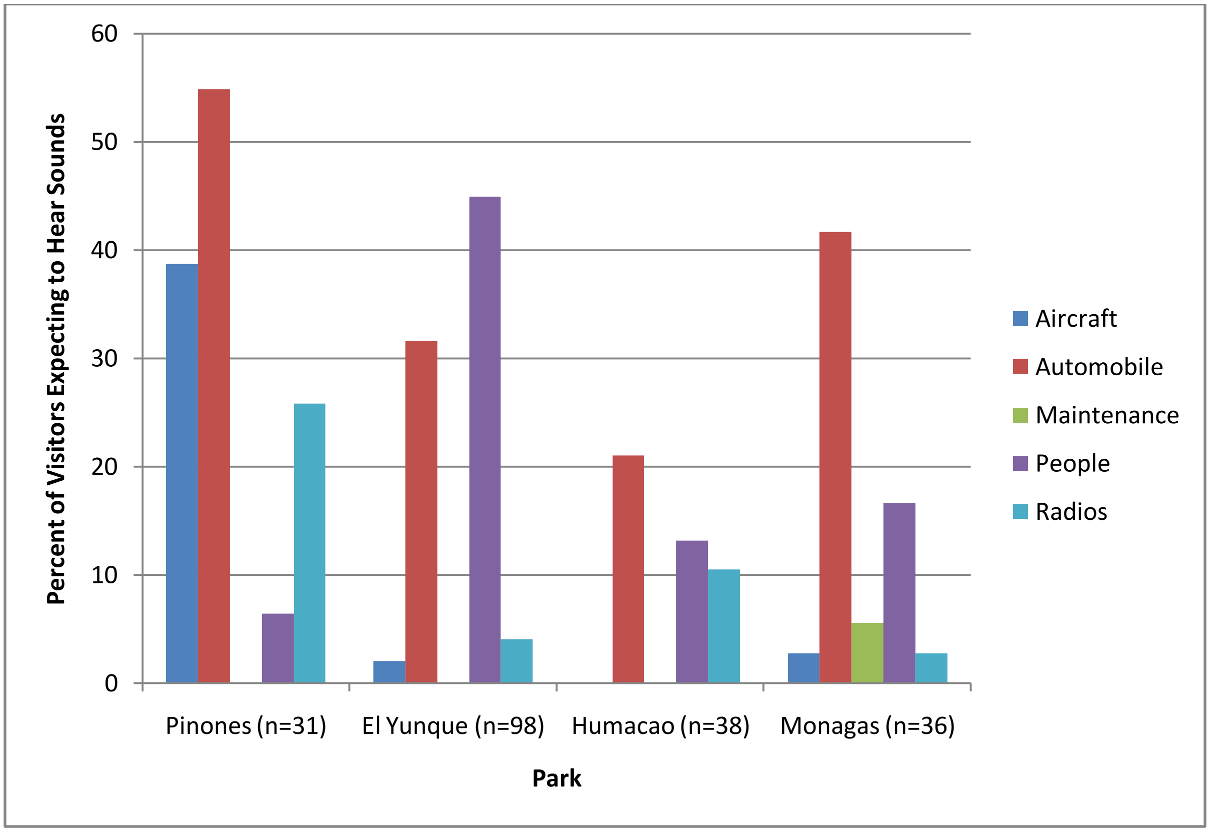


Figure 26 – Non-natural Sounds Visitors Expected to Hear

From the graph, one can determine that automobiles were by far the most expected non-natural noise. In fact, in all four of the parks over 20% of respondents listed automobiles as an expected source of non-natural sound. Almost 40% of respondents expected to hear aircraft noises in Piñones, which is not surprising given its proximity to San Juan International Airport. An even higher percentage (54.8%) expected also to hear automobiles, however, which may seem surprising except when one remembers that a prime coastal road traverses the entire length of the park. The graph also shows that few people expected their visit to be interrupted by the noise of maintenance work. This shows that although many non-natural sounds were expected, visitors felt the sounds would be caused by external sources and not the park personnel themselves.

The following question on the survey inquired about what non-natural sounds that participants found annoying during their current visit to the park. Shown below in Figure 27 are the percentages of visitors in each park who reported being annoyed by any of the categorized noises; aircraft, automobiles, maintenance, people and radios.

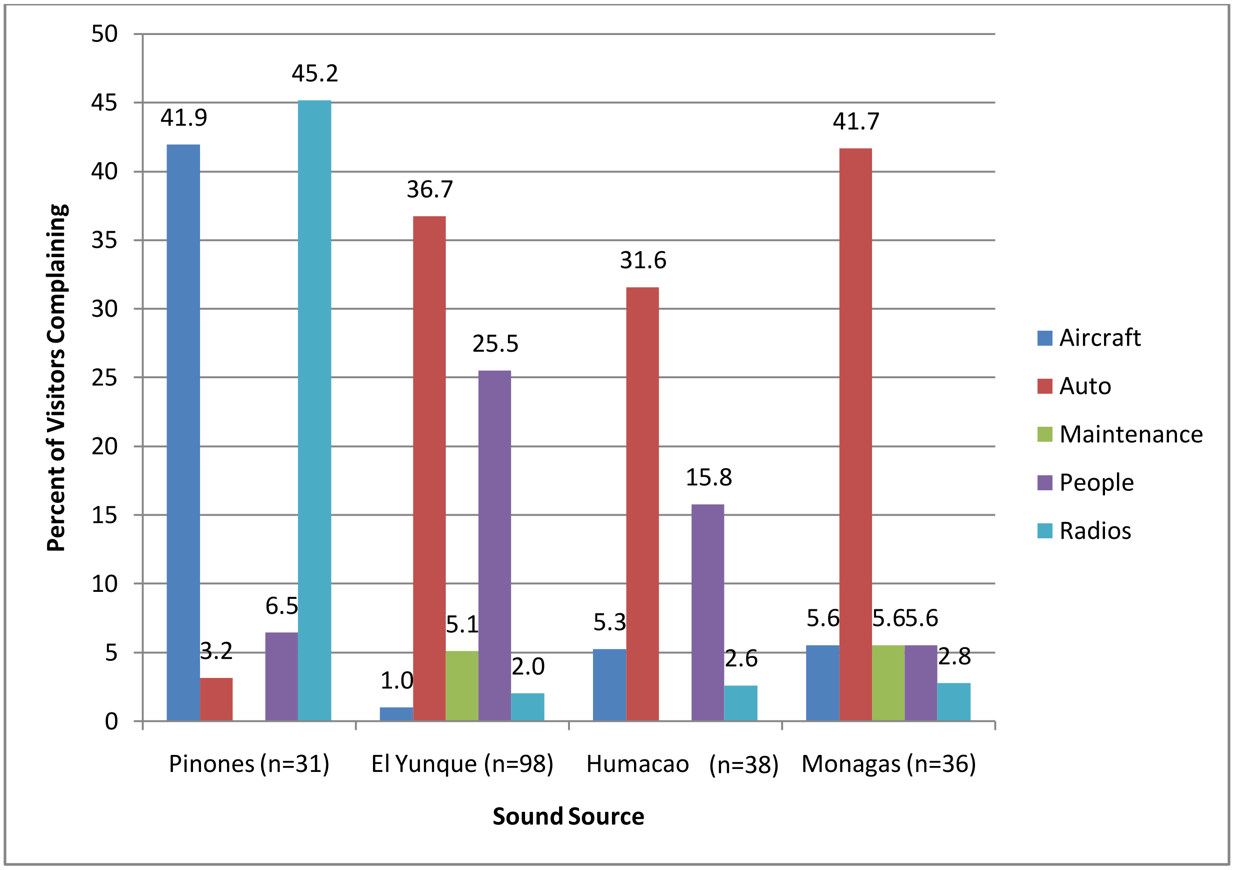


Figure 27 - Percent of Visitor Complaints by Sound Source

There are a few important conclusions that can be made from this data. One very obvious conclusion is the difference between Piñones and the rest of the parks, Humacao, El Yunque, and Monagas. Piñones is the only park were a large percentage of visitors responded that they were annoyed by aircraft and radios. In fact, 41.9% of visitors complained about hearing aircraft in Piñones while 45.2% complained about hearing radios. This is likely due to the close proximity of the airport and the main use of Piñones for exercising. In Humacao, El Yunque, and Monagas, the main complaints were automobiles and people. This is shown by a level as high as 41.7% of complaints about automobiles in Monagas and 25.5% of complaints about people in El Yunque. These high percentages are most likely due to the closeness of roads around and within these three parks. Maintenance was only slightly mentioned and can be seen as a problem only occasionally.

In order to determine how bothersome the non-natural sound sources actually were to park visitor experiences, the questionnaire asked the participants to rate the level of annoyance caused by each non-natural sound source that they were annoyed by. In order to provide more meaningful results, the project group only calculated the annoyance levels of sources heard by at least 25% of the visitors for each park. The data from these calculations is shown below in Figure 28 where the average annoyance level for each sound for each park is shown separated by source.

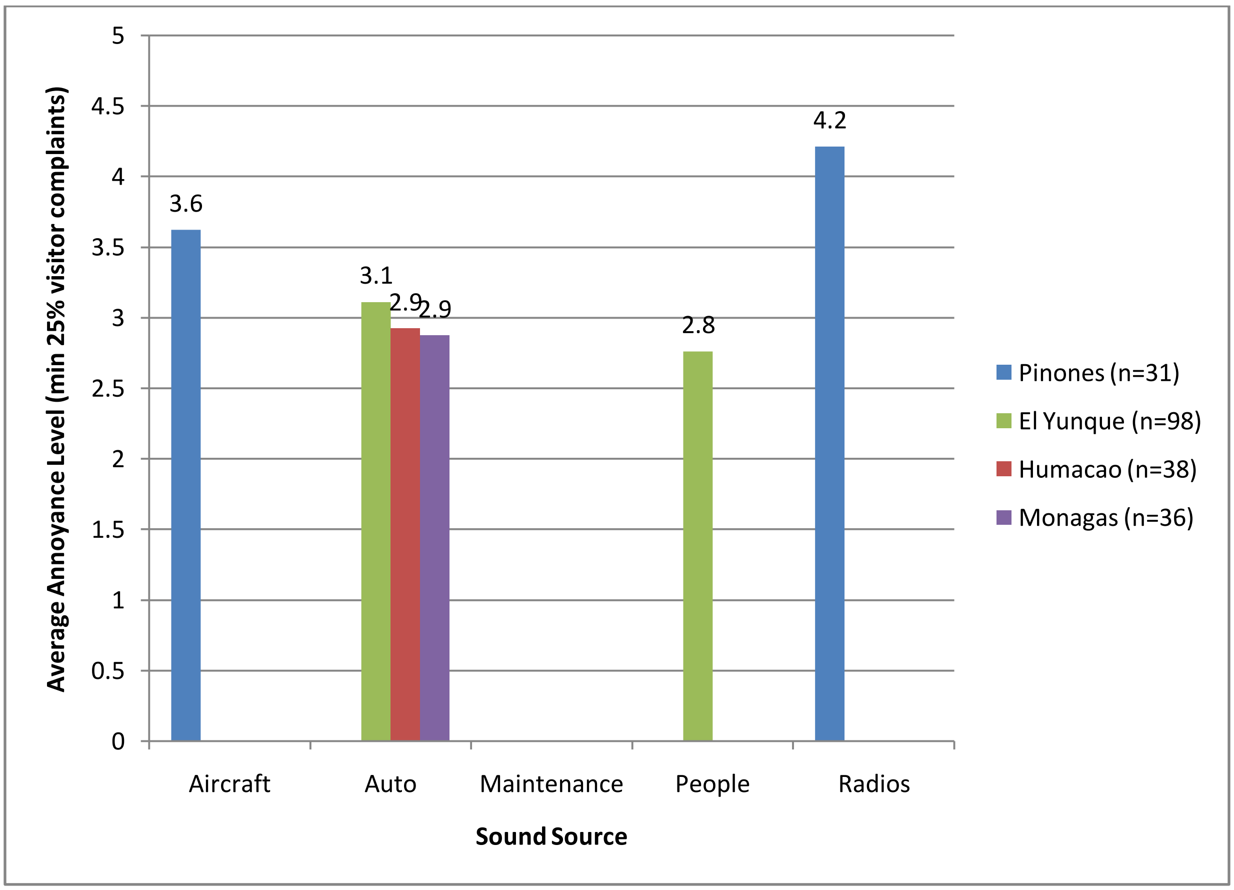


Figure 28 - Average Annoyance Levels for Commonly Heard Sound Sources by Source

As stated previously, the amount of respondents complaining about hearing maintenance was not enough to make any conclusions. Figure 28 does show, however, that in El Yunque, Humacao and Monagas, automobiles were claimed to be around a level of 3 out of 5 for annoyance to the park experience. A level of 3 on the 1 to 5 scale is equal to a moderate level of annoyance. The highest level of annoyance was caused by radios in Piñones with a 4.2 average. Piñones was also the only park where aircraft were found to be annoying with a level of 3.6. Finally, the only park where people were a slight problem was El Yunque where the level of annoyance was 2.8. Figure 29 shows that this in a slightly different manor, showing the annoyance levels by park.

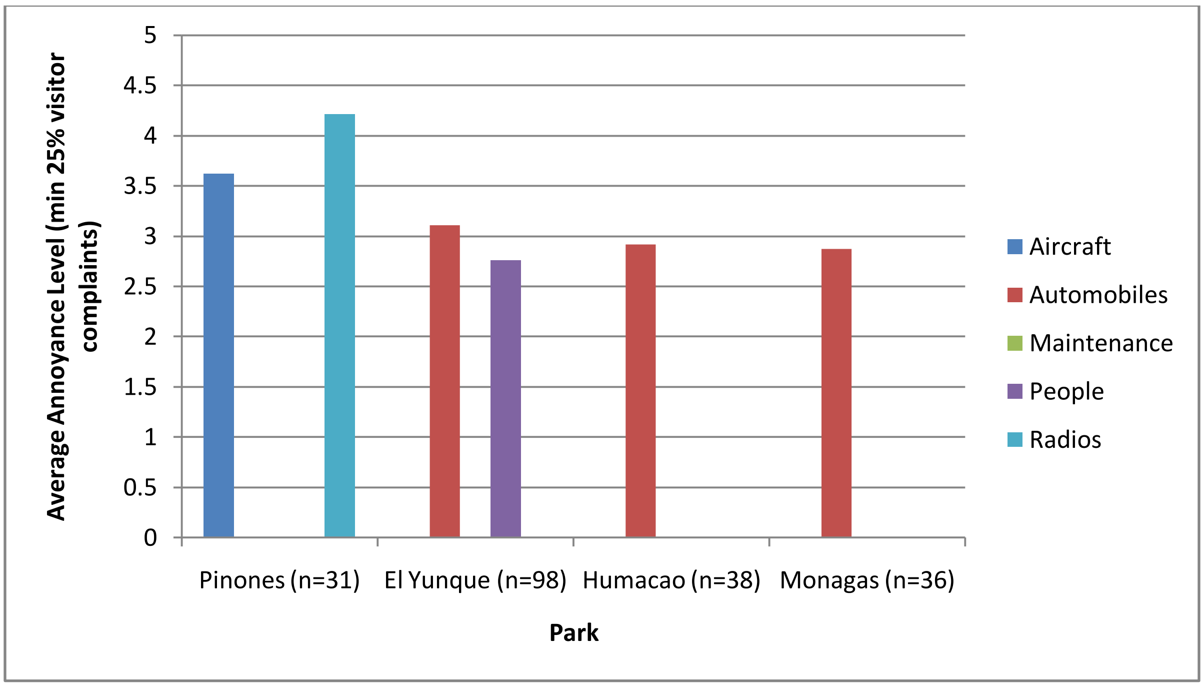


Figure 29 - Average Annoyance Levels for Commonly Heard Sound Sources by Park

Another question asked respondents to rate how much noise from non-natural sounds interfered with their enjoyment of the natural scenery, their enjoyment of hiking and exercising, and their enjoyment of the natural quiet. This question was also based on a five point scale where 1 was “not at all interfered” and 5 was “extremely interfered.” Figure 30 below shows a graphic example of interference levels by park of the main park activities.

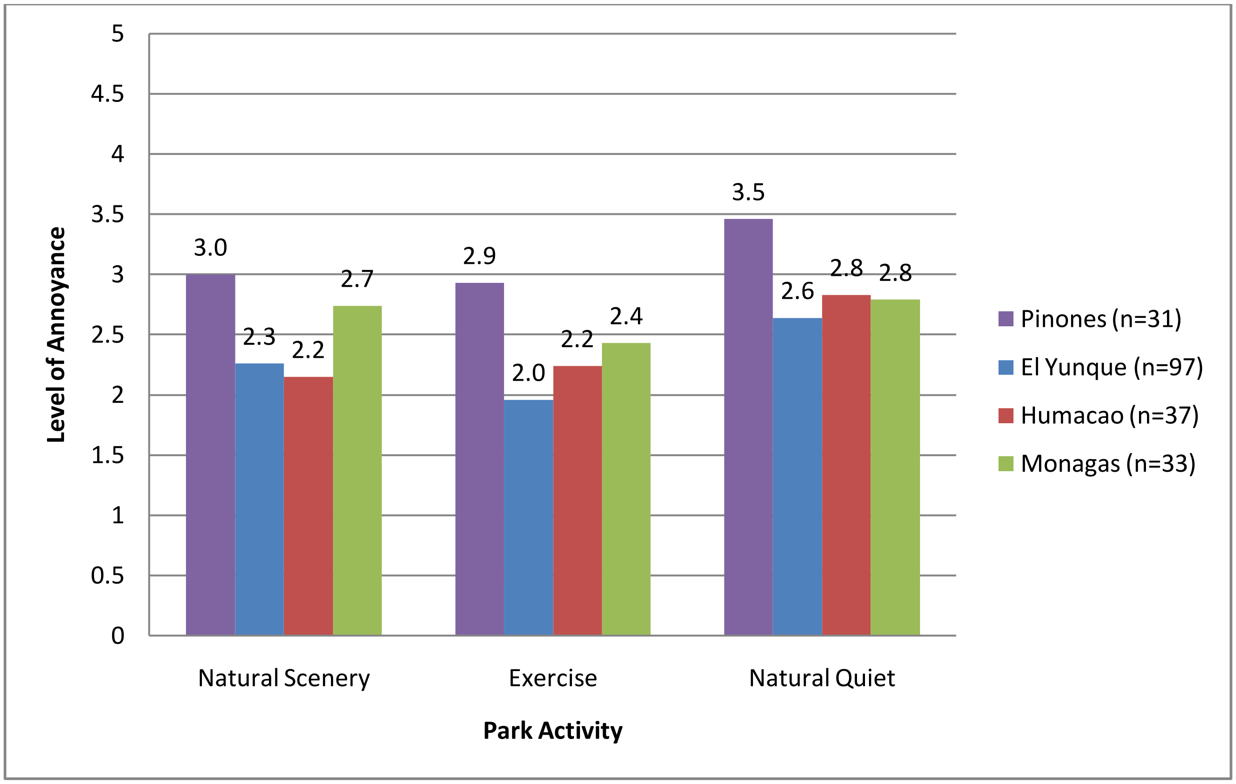


Figure 30 - Noise Interference of Park Activities by Park

Even though the level of importance for park activities was either very or extremely important, previously shown in Figure 30, the levels of interference of non-natural sounds on these activities were only slightly interfering. The only park which had a level of interference 3.0 or higher was Piñones. This data is a clear example that even though visitors might find non-natural sounds annoying to their visit, there is still not a noteworthy level of interference on the main park activities conducted by visitors.

In order to gain feedback on the level of concern visitors to parks in Puerto Rico had for the problem of noise pollution throughout the island, the questionnaire asked the participants to rate how important the study of noise pollution was. This level of importance was rated on a 1 to 5 scale where 1 was “not at all important” and 5 was “extremely important.” Figure 31, below, shows the number of responses for each level of importance.

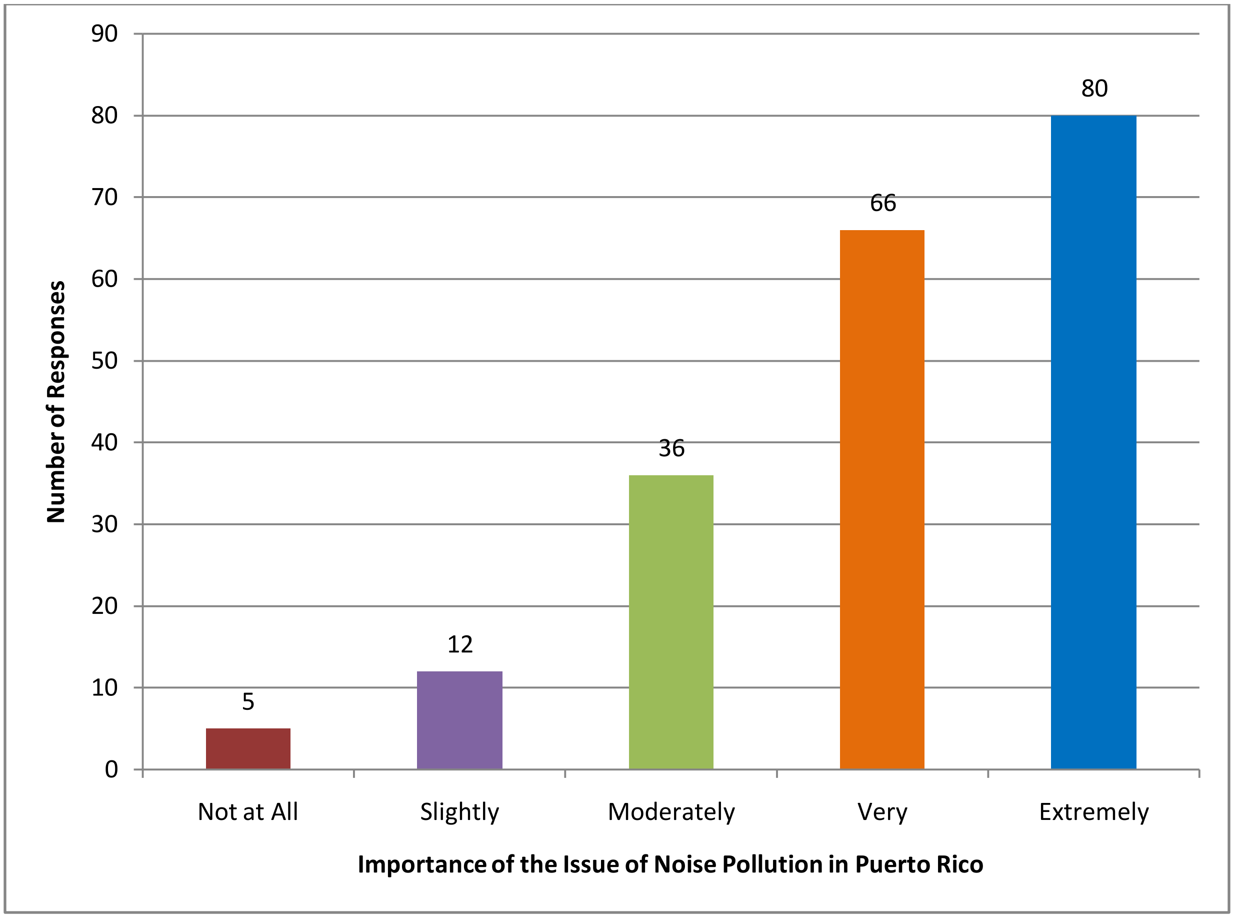


Figure 31 - Responses to the Issue of Noise Pollution in Puerto Rico (n=199)

As shown in Figure 31, most participants (73%) responded that studying noise pollution in Puerto Rico was either "very" or "extremely" important. This is an important statistic because it gives reason and backing to the projects and research conducted by the JCA and other organizations completing similar studies. This data shows that visitors are aware and concerned about the levels of noise pollution in the parks and across the entire island of Puerto Rico.

Discussion and Conclusion

In order to determine whether or not visitor experience is affected by non-natural noise in parks, the project team gathered sound profiles from each park using the Norsonic-121. The team also manually identified noise sources and decibel levels of sound sources using the Bruel & Kjaer 2232 while completing thirty minute sound logs. The data collected by the Norsonic-121s provided the project team and the JCA with an average sound profile for each of the four parks and reserves in our study. The team also administered a total of 203 visitor surveys collectively in Piñones, El Yunque, Humacao, and Monagas. The surveys provided a basic understanding of how noise affected park visitor experience, as well as what noise sources were the most bothersome to park visitors. Based on all of the data collected through these three methods, the team has drawn several conclusions that are discussed in the following paragraphs.

The first, and possibly the most important conclusion, that can be made from this project is that park visitors in general do feel that noise pollution is an important issue that needs to be addressed. Over 91 % of those surveyed said that they would rate the issue of noise pollution as "either moderately important," "very important," or "extremely important." This statistic provides justification for future research on noise pollution.

Visitor surveys indicated that noise caused by motor vehicles was the principal source of noise annoyance in the parks and reserves that the project team studied. Figure 32 shows what percentage of visitors noted each specific sound source as annoying (i.e. rated is as 2 or above on a 5 point scale). The average annoyance level of each source is listed above each bar on the graph.

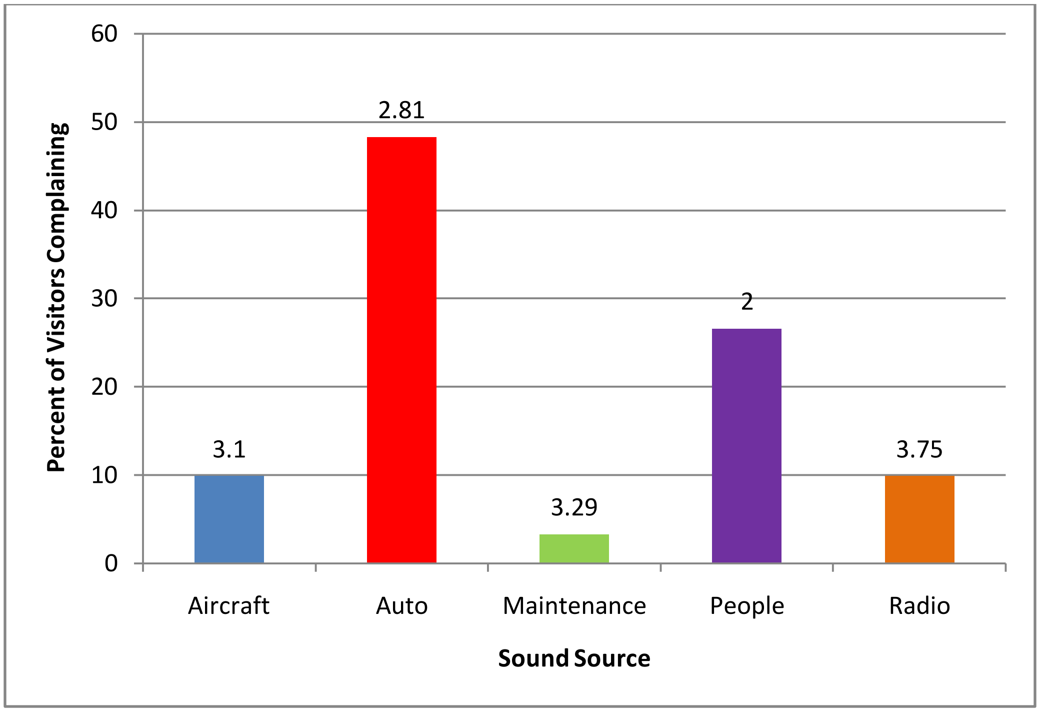


Figure 32 - Percent of Visitor Complaints by Noise Source with Average Annoyance Level (n=203)

While Figure 32 shows that autos do not have the highest annoyance level, it is the most frequent complaint. Almost half of all visitors surveyed, indicated motor vehicles as a noise issue. Radios had the highest average annoyance level, but less than 10% of visitors complained about them, leading the project team to conclude that radios are not as big of an issue as cars or people for example.

Through the surveys and observational logs, many noise sources were identified. Much of the project has sought to which noise sources interfere with visitor experience and the average annoyance level of each source and the team did just that. Just about every visitor survey yielded a noise complaint, but despite all of the complaints, the team found that visitors still enjoy their visits. One of the questions on the survey asked the respondent to rate their overall park experience on a scale of 1 to 5 with 1 being not at all enjoyable and 5 being extremely enjoyable. Figure 33 shows the overall level of enjoyment of all 203 surveys combined.

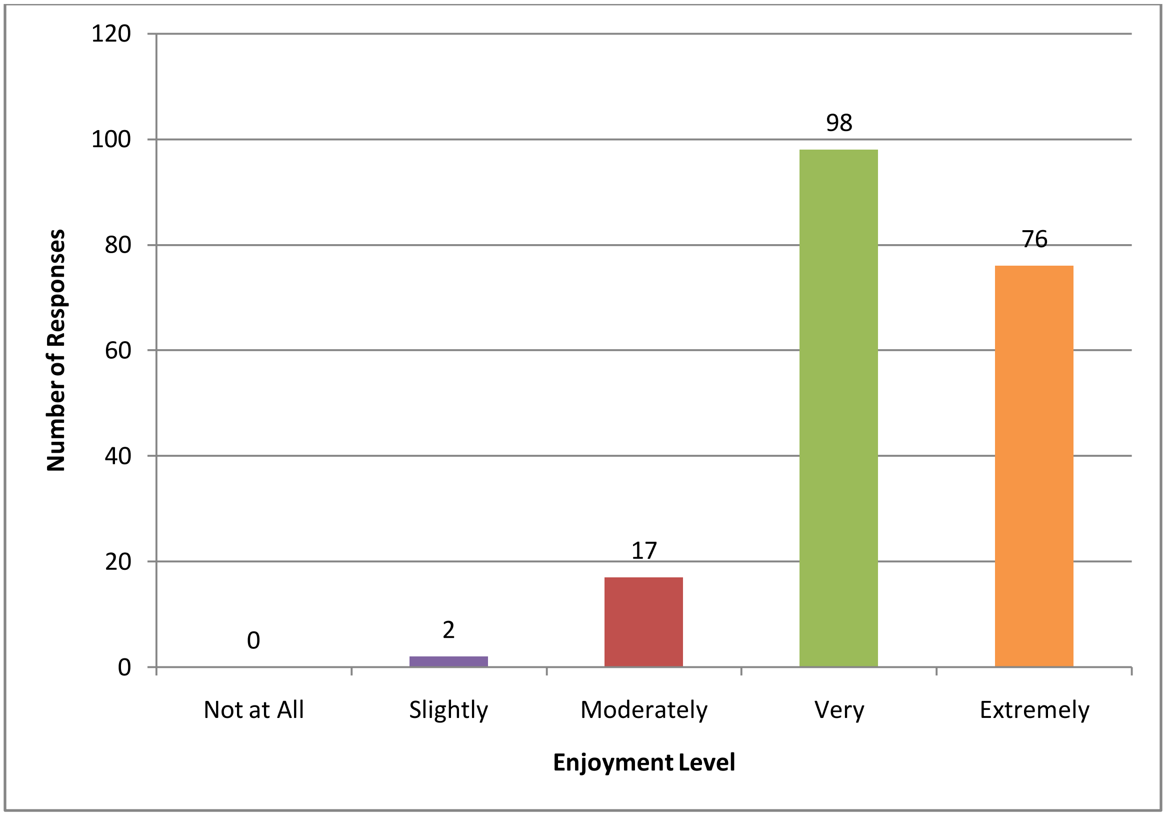


Figure 33 - Enjoyment Level by Visitor Response (n = 193)

As Figure 33 shows, the vast majority of park visitors found their visit either very enjoyable or extremely enjoyable. This means that despite noise complaints, visitors are still enjoying their visits to the parks and reserves. Noise may not completely interfere with a park visit, but visitors still find noise annoying to their visit and work in the area of noise control is still important.

The project team found substantial differences between and among the parks due to differences in locations, ecosystems, weather patterns, etc. Each sound profile was different, the sound sources differed, and the sound levels varied from park to park. Therefore, the project team concluded that concise, general statements often cannot be made for parks in Puerto Rico overall. The recommendations discussed in the next section may not necessarily apply to each and every park and reserve in Puerto Rico. Each park is different and those differences must be taken into account when deciding how to deal with possible noise issues in parks or reserves.

Recommendations

The project team feels that the most important recommendation that can be made in regards to this study is more research. Eight weeks was not enough time to gather a lot of data. The team ran into several obstacles, especially with the Norsonic-121 data, and more time would have allowed for more data collection. It is recommended that in the future when attempting to gather information on visitor experience, perceptions, and attitudes about noise in parks and reserves more surveys need to be conducted over an extended period. The team found that it was much more efficient to survey on the weekends rather than on weekdays. This is because in most parks and reserves, visitor attendance is much higher on a Saturday or a Sunday. The time constraints made it difficult to gather many surveys, especially in parks with a low visitor attendance. More surveys would make the results a research project such as this much more compelling and would allow for greater differentiation by potentially important characteristics, such as age and gender. It will also be important to gather both monitoring and survey data on weekdays, weekends, and holidays since the characteristics of the visitors as well as the sound profiles of the parks will vary.

- It was evident that, in general, the biggest problem when it comes to noise in parks according to public opinion gathered in the project team's surveys is noise caused by motor vehicles. This was the most commonly noted annoyance in all four reserves that were surveyed. All parks studied had a road or allowed vehicles to operate where visitors frequented. Even though autos were not the most frequently noted sound source in the observational logs, it was the most frequently noted in visitor surveys. The focus of this project was on visitor experience, therefore the opinions voiced on the visitor surveys trump the observational logs completed by the project team. Several suggestions left at the end of the surveys by visitors mentioned not allowing vehicles to drive near the trail-head or within the park at all. One option that could help with the noise problem caused by vehicle noises is to have only one parking lot at the very beginning of the park. Deny vehicle access into the park, except for park shuttles, which can take visitors from the parking lot to other parts of the park. This suggestion could be best implemented in El Yunque given the arrangement of the trail heads and access roads. If there was just one parking lot at the bottom of the mountain and a shuttle to drive visitors up and down the mountain, then a large amount of traffic noise would be eliminated. The shuttle drivers could be instructed to not honk their horns or play loud music.

- Piñones and Monagas are both located near highways adding traffic sounds to the normal background noise. The Bruel & Kjaer 2232 could not separate the background traffic noise apart from the natural soundscape because the traffic noise was constant. The only time vehicle sounds really stood out was when a car horn beeped or a large tractor trailer was shifting gears, otherwise the traffic sounds blended into the background as far as the Bruel & Kjaer 2232 was concerned. Even though the technology could not separate the sounds, the human ear can and therefore, traffic noise does interfere with the visitor experience. Our recommendation for Piñones would be to put up a sound barrier on the side of the main road. A sound barrier made of wood or concrete would not be very aesthetically pleasing, but one made out of dirt mounds would look more natural. A sound barrier is the best option in Piñones because the road is just a few feet from the reserve and would be highly effective in mitigating the noise.

  A barrier in Monagas, though, would not at all be effective because the highway sounds that are heard are from a far away highway. Up on the hills, away from the lower recreational area of Monagas, the traffic sounds can be heard most clearly, since nothing except air is blocking the noise. A barrier cannot be built high enough to help mitigate the noise because the hills are much higher than the highway. In the lower area of the reserve, there are plenty of trees to block a lot of the noise, creating a natural sound barrier for the nearby highway. Our recommendation for dealing with traffic sounds in a park or reserve with in a situation such as the one in Monagas is simply more research in possible noise attenuating techniques.

- Noise caused by people, including yelling, talking, and radios, were the second most frequently mentioned noise sources the visitors found bothersome. The noise logs completed by the project team support this finding because a 46.3 % of the non-natural sounds recorded were noises made by people talking, shouting, and screaming. It is not feasible or polite to just tell people to be quiet because visitors may feel they are not welcome into the reserve or that they cannot enjoy the visit by talking with their friends and family. They only viable option in dealing with visitor noise is to just inform people with signs and brochures about how noise affects visitor experience. Also, challenging visitors to listen to the natural soundscape and see what noises they can identify (such as birds, frogs, running water) may keep visitors quieter. Putting up friendly signs in parks and reserves that briefly inform visitors that the natural soundscape of the area are a part of the visit and of the park itself will not necessarily keep people quiet but it may help visitors to think twice before turning up a radio or start yelling. It may not be the most effective approach, but it will not offend visitors or make them feel unwelcome while still informing them that the soundscape is important. More research is needed to explore what techniques help to encourage visitors to be quieter in park settings.

- Noise caused by routine maintenance in a park or natural reserve is relatively infrequent, but very bothersome to visitors. While loud maintenance activities are sporadic, the survey indicates that people are very annoyed by such activities. The noise logs also indicate that sounds from maintenance and vehicles can be very loud. Consequently, the project team recommends reducing maintenance activities and noise to a minimum during peak visiting hours whenever possible. If maintenance work cannot be completed before or after visiting hours, then such work should be done very early in the day before most visitors arrive or late in that day as the leave. Also, putting up signs at the entrance of the reserve informing visitors that maintenance work is being done in certain areas of the reserve would alter visitor expectations. Such information could allow them to adjust their hiking routes, choice or picnic area, and so forth to minimize the level of interference with their enjoyment of the park. Figure 34 compares annoyance levels of specific sound sources when visitors indicated that they expected to hear that specific sound before they entered the park versus those that did not expect to hear the sound.

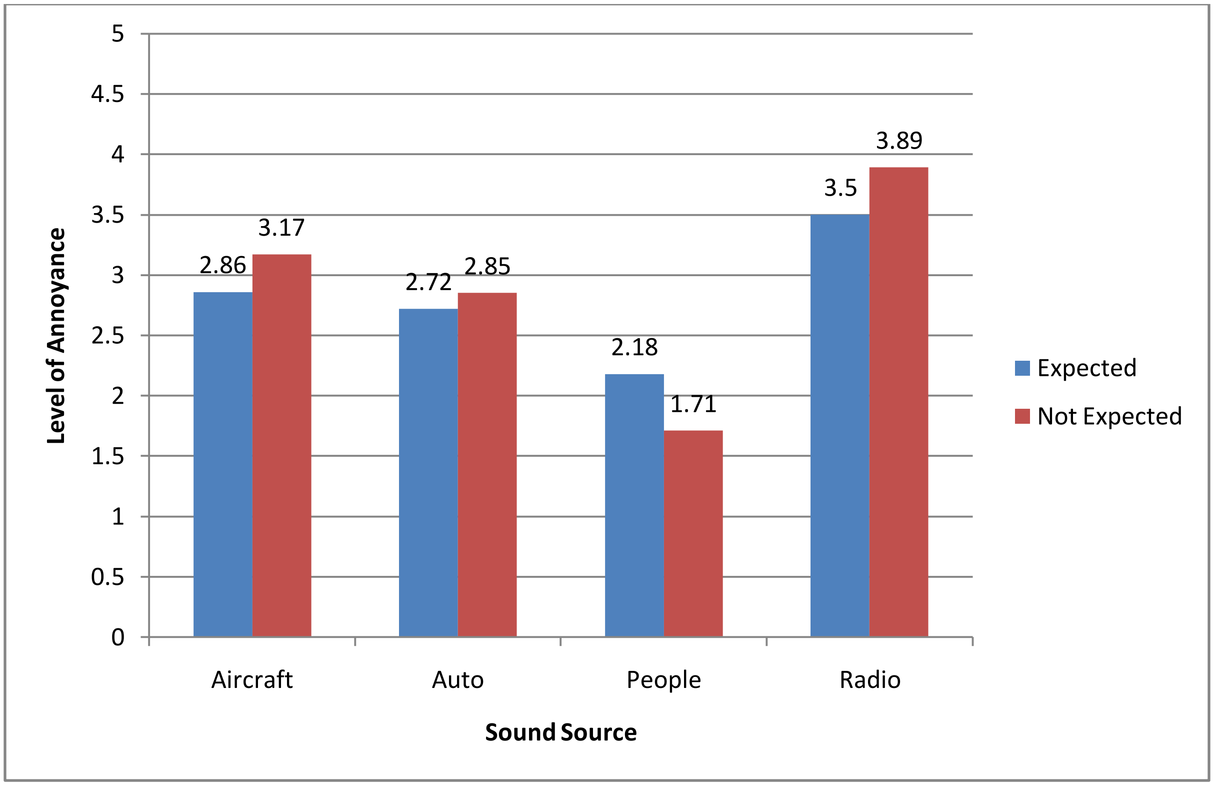


Figure 34 - Expected vs Non-expected Annoyance Reactions to Sources of Noise

The graph shows that in all categories, except noise from "people", the average annoyance level was higher when visitors did not expect to hear that specific noise. There are many reasons why the "people" category does not follow this trend. Perhaps this is because the types of noises caused by people range greatly from quiet conversations to loud yelling. Visitors may have expected to hear conversations, but not yelling and screaming. Anders Kjellberg (1996) says:

> A predictable stressor offers greater possibilities to prepare oneself for the stressor, and the predictor also implicates that there are periods during which the person does not have to be prepared for the stressor. Accordingly, a variable noise should be less annoying when the changes are expected then when they are unexpected. Similarly, the person who operates a machine and, this, controls its noise should be less annoyed by it than are other people exposed to the same noise.

Kjellberg is saying that when a noise is expected by someone, then that person will be less annoyed by that noise. Conversely, if a noise is unexpected, then a person will find that noise more annoying than they would have had they expected to hear this noise. As an example, if somebody expects to hear vehicle sounds in a certain area of a park, then they will be less annoyed by the vehicle noise than they would had they not expected to hear it before they walked into the park. This statement is what the data from this project is showing.

- Airplane noise was another source of annoyance in Humacao, Monagas, and Piñones. Aircraft overflights were not often mentioned in visitor surveys in El Yunque. The team noticed flights were not recorded in the sound logs in El Yunque either. This lack is likely because the natural soundscape of El Yunque is slightly louder than other parks due to the increased amounts of rain, waterfalls, and fauna. The massive amount of tree cover would also naturally help abate noise caused by any aircraft flying over. There is not too much that can be done in Piñones to stop the noise by aircraft as Piñones just outside the boundary fence of in San Juan International Airport. As for Humacao and Monagas, and many other parks and reserves, the most feasible option is again to inform visitors of what types of sounds they will hear in the reserve including the occasional airplane flying over. It is not realistic to ask the FAA to redirect flights so that they do not fly over these reserves mainly because the parks and reserves the team studied are much too small. Working with the FAA to reduce airplane noise may be a possibility for large, national parks, but not for small reserves that are scattered around the island of Puerto Rico and are not home to endangered species of fauna. However, airplane manufacturers are doing their best to design airplanes to be quieter so that they are less bothersome to anybody within earshot (Manuel, 2005).

The project team feels that again that the most important recommendation that can be made as a result of this project is that JCA and other need to conduct more research. The more surveys completed in regard to visitor opinion on noise in parks and reserves, as well as the more sound data collected, the stronger the results and findings will be. Other than more research, education is key. Informing park visitors of what sounds they can expect to hear, whether it be aircraft, maintenance, or recreational vehicle noise for example, will help bring the annoyance level down and the level of enjoyment up. Proper signage at the entrance of reserves and parks are a simple and polite way of keeping visitors informed and, most importantly, pleased with their visit.

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Appendix A - Sponsorship by Junta de Calidad Ambiental

The Junta de Calidad Ambiental (JCA) or Environmental Quality Board, is a government agency responsible for environmental protection in Puerto Rico. The JCA's mission is

> "Protecting the quality of the environment through the control of pollution of air, water and soil, and noise pollution; use all means and practical measures to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social and economic needs and any others that may arise with the present and future generations of Puerto Ricans" (www.jca.gobierno.pr 2008).

The vision of Junta de Calidad is to be a public service board that develops policies that protect the environment and natural resources and move Puerto Rico towards long-term sustainable development. The JCA tries to accomplish this mission by working with other government agencies, businesses, academic institutions, and other organizations involved in managing environmental conditions in Puerto Rico,.

Junta de Calidad was formed in reaction to a growing concern about the rapid development of Puerto Rico during the 1960s and the adverse impact this development was having on the environment and natural resources of the commonwealth. This growing concern lead the Puerto Rican House of Representatives to set up a committee dedicated to environmental concerns. The Office of the Secretary of Natural Resources was in charge of this committee. By 1970, the House realized that it was imperative to create a unified public policy for the island, resulting in the passage of the Public Environmental Policy Act of Puerto Rico. This concern, in turn, lead to the creation of the Junta de Calidad Ambiental or Environmental Quality Board. The main function of this board was to create public policies that protect the environment and the health of the residents of Puerto Rico. The Junta de Calidad Ambiental is made up of several areas such as the department of water quality, air quality, pollution control, noise control, and scientific advisory. The Board has been active in these areas as well as in establishing a public policy that enhances environmental quality for the last 30 years and continues to do so today.

The Puerto Rican government has proposed a budget of $31,690,000 for Junta de Calidad in the 2008 fiscal year. Figure 5 shows that 36% of these funds go towards federal funds, 38% of these funds go towards joint resolution, and 26% of these funds go towards state special funds. (www.presupuesto.gobierno.pr 2008).

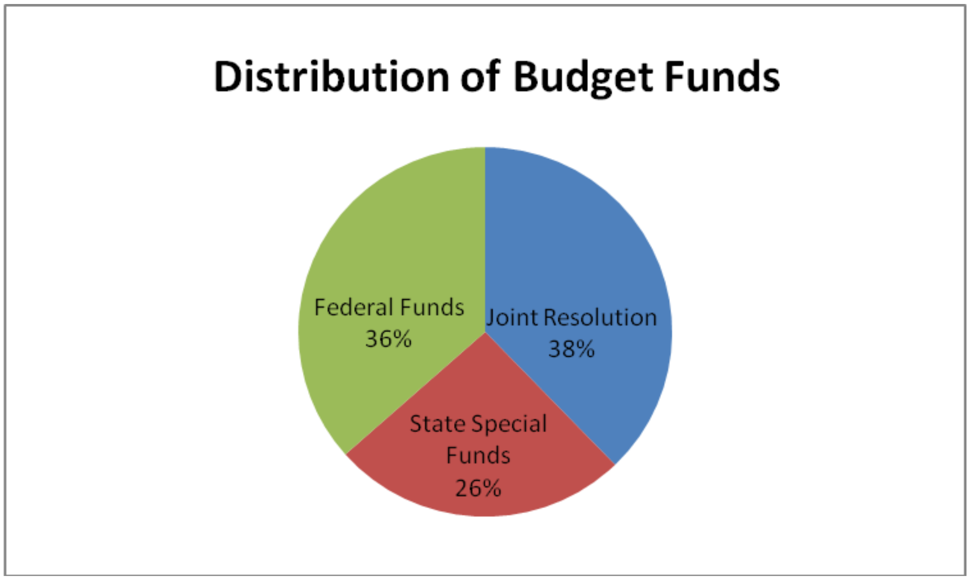

Figure 35 - Distribution of Budget Funds

Federal Funds refer to Federal grants, while Special State Funds come from state permits, fines, and bills, in accordance with Law No. 416, the Law on Public Policy Environment. This funding will allow the agency to carry out all of its commitments in protecting and maintaining environmental quality.

The Governing Board oversees the operations of the Junta de Calidad. The Board comprises three associate members and one alternate member each of whom serves a four year term. The members are appointed by the Governor of Puerto Rico and approved by the Senate. The Board meets at least once a week and operates on a majority vote. This board acts as an advisor to the Governor on all environmental public policy issues. The JCA ensures that the environmental laws and standards are met in addition to promoting regulations pertaining to the quality of the environment. They manage the delegation of any legislation and actively pursue violators of laws or regulations.

Noise is one of the many problems with which the JCA is concerned, and is the focus of the proposed project. The JCA has set up a noise control council to address problems with noise pollution. The council defines noise as undesirable sounds not made in nature. The noise problem is viewed as a great inconvenience to the people of Puerto Rico. According to public opinion surveys completed by the JCA, the most annoying noise sources include various modes of transportation, radios, televisions, businesses, machineries, electric plants, and heavy equipment. However, the noise is not just considered an inconvenience, but it also contributes to health problems such as stress, headaches, sleep deprivation, and cases of partial or total hearing loss (www.jca.gobierno.pr 2008). In public places like parks, outdoor cafes, and beaches, the noise significantly reduces the experience and enjoyment that these places are meant to offer. It is the goal of the Noise Control Council to perform studies on noise, develop ordinances regarding noise, and determining the effectiveness of such ordinances.

Appendix B - Park Selection Matrix

The Matrix shown on Table 15 is the original park matrix used to help compare and contrast many of the different parks in Puerto Rico when the project team was decided which locations to use for this project.

Table 15 – Original Park Selection Matrix

Park	**Location**	**Size**	**Ecosystems**	**# of Visitors**	**Proximity to Airport**	**Proximity to Major Highway**	**Distance from San Juan**
El Yunque	Northeast, near Jimenez	28,000 acres	Tropical Rainforest	600,000/year	~25 miles	~7 miles	~31 miles
Cerro El Buey	Vieques	799 acres	Mangrove Beach Rocky Coast Savannah Coastal Dry Forest	Unknown	~4 miles	None on island	~67 miles
Los Montes Oscuros	Salinas	7,281 acres	Secondary Dry Forest Volcanic Rock Mountains Coastal Flat Plains	Privately Owned – Unknown Visitation	~21 miles	~0.5 miles	~50 miles
Barrio Rabanal	Cidra	15 acres	Secondary Forest	Unknown	~ 37 miles	~10 miles	~34 miles
Rio Portugues	Adjuntas	42 acres	Humid Forest River	Unknown	~18 miles	~18 miles	~76 miles
Punta Yeguas	Yabucoa	280 acres	Humid Forest Beach	Not open to public	~57 miles	~4 miles	~44 miles
Hacienda la	Manati	2,212	Karst Forest	Currently	~35 miles	~5 miles	~32

Esperanza		acres	Pterocarpus Forest Evergreen coastal humid Forest Estuaries Wetlands Alluvial plains	being worked on to be available to the public			miles
La Parguera	Lajas	1,234 acres	Dry Forest Salt Flats Mangrove Fringes Rocky Coast Bioluminescent Bay	Exact # Unknown. Popular Tourist Area	~14 miles	~4 miles	~107 miles
Bahia Ballena	Guanica-Yauco	162 acres	Dry Forest Mangrove Forest Inlets and Coves Lagoons Coastal Scrub Beach	Unknown	~25 miles	~3 miles	~97 miles
Punta Guaniquilla	Cabo Rojo	313 acres	Dry Forest Mangrove Fringes Lagoons Coastal Scrub	Unknown. Popular bird watching location.	~9 miles	~5 miles	~116 miles
Jorge F. Sotomayor del Toro	Caguas	63 acres	Humid Tropical Forest	Unknown	~20 miles	~ 0.5 miles	~21 miles
Pterocarpus Forest of Humacao	Humacao-Naguabo	766 acres	Pterocarpus Forest Lagoons Mangrove Forest	Unknown	~12 miles	~1 miles	~ 41 miles
Hacienda Buena Vista	Ponce	79 acres	Humid Subtropical Forest	Unknown. Open to the public.	~ 4 miles	~ 2 miles	~ 74 miles
Las Cabezas de San Juan	Farjado	321 acres	Dry Forest Rocky Coast	Unknown. Open to the	~ 4 miles	~ 1 miles	~38 miles

			Bioluminescent Lagoon Mangrove Forest Thalassia Beds	public.			
Cristobal Canyon	Aibonito-Barranquitas	1,215 acres	Humid Subtropical Forest Rocky Islets	Unknown	~36 miles	~ 8 miles	~36 miles
Rio Encantado	Ciales-Florida-Manati	802 acres	Karst Forest Cave System	Unknown	~ 39 miles	~ 8 miles	~40 miles
Pterocarpus Forest of Dorado	Dorado	31 acres	Pterocarpus Forest Mangrove Forest	Unknown	~18 miles	~ 3 miles	~20 miles

Appendix C – Visitor Survey (English)

Park Visitor Questionnaire

Environmental Quality Board

Worcester Polytechnic Institute

Hello. I am helping the Environmental Quality Board of Puerto Rico with a survey of visitors to (PARK NAME). The information visitors give us will help managers identify any problems in the park and enable them to better serve you. I would appreciate a few minutes of your time to answer some questions about your visit. Your participation in the survey is voluntary, and your answers are confidential and anonymous.

THIS FIRST GROUP OF QUESTIONS IS ABOUT YOUR CURRENT VISIT TO (NAME OF PARK).

1. On what date and time did you start your visit to (NAME OF PARK)? (FILL IN BLANK)

   Date: Month ____________________ Day: __________

   Time: _____ _____ : _____ _____ a.m./p.m.

2. Is this your first visit to (NAME OF PARK) or have you visited the park before? (CIRCLE ONE NUMBER)

   1 First visit → (SKIP TO QUESTION 4)

   2 Visited park before

3. If you have visited this park before, including this trip, approximately how many times have you visited (NAME OF PARK) in the last two years? (FILL IN BLANK)

   __________ Total times

4. Overall, how enjoyable has your visit been to (NAME OF PARK) during this trip? Has your visit been not at all, slightly, moderately, very, or extremely enjoyable? (CIRCLE ONE NUMBER)

1 Not at all enjoyable
2 Slightly enjoyable
3 Moderately enjoyable
4 Very enjoyable
5 Extremely enjoyable

5. How important was each of the following reasons for visiting (NAME OF PARK)? Would you say that each reason was not at all important, slightly, moderately, very, or extremely important for your visit? (CIRCLE ONE NUMBER FOR EACH REASON)

Would you say that…	**Not at All Important**	**Slightly Important**	**Moderately Important**	**Very Important**	**Extremely Important**
viewing the natural scenery was…	**1**	**2**	**3**	**4**	**5**
exercising or hiking was…	**1**	**2**	**3**	**4**	**5**
enjoying the natural quiet and sounds of nature was…	**1**	**2**	**3**	**4**	**5**
Other reason: _________ ____________________ ____________________	**1**	**2**	**3**	**4**	**5**

YOU HEAR MANY NATURAL SOUNDS IN PARKS, SUCH AS ANIMALS, RUNNING WATER, AND LEAVES RUSTLING. OCCASIONALLY, YOU MAY ALSO HEAR NON-NATURAL SOUNDS IN PARKS. THIS NEXT GROUP OF QUESTIONS IS ABOUT NON-NATURAL SOUNDS AT (NAME OF PARK).

6. What non-natural sounds, if any, did you expect to hear at (NAME OF PARK) prior to your current visit? (FILL IN BLANKS)

   1 ________________________
   2 ________________________
   3 ________________________
   4 **None**

7. Which non-natural sounds, if any, did you hear during your current visit to (NAME OF PARK)? Also, please classify each sound as not at all annoying, slightly, moderately, very, or extremely annoying. (FILL IN BLANK AND CIRCLE THE NUMBER CORRESPONDING TO THE LEVEL OF ANNOYANCE FOR EACH SOUND)

	Not at All	Slightly	Moderately	Very Much	Extremely
______________________	1	2	3	4	5
______________________	1	2	3	4	5

____________________	**1**	**2**	**3**	**4**	**5**
____________________	**1**	**2**	**3**	**4**	**5**
____________________	**1**	**2**	**3**	**4**	**5**

8. How much did noise from non-natural sounds interfere with each of the following aspects of your visit at (NAME OF PARK)? Did the sound from external noises interfere with the aspect not at all, slightly, moderately, very much, or extremely? (CIRCLE ONE NUMBER FOR EACH ASPECT)

Would you say that…	**Not at All**	**Slightly**	**Moderately**	**Very Much**	**Extremely**
enjoyment of the site…	**1**	**2**	**3**	**4**	**5**
enjoyment of exercising or hiking…	**1**	**2**	**3**	**4**	**5**
appreciation of the natural quiet and sounds of nature…	**1**	**2**	**3**	**4**	**5**
Other aspect: _________ ____________________ ____________________	**1**	**2**	**3**	**4**	**5**

9. In Puerto Rico there are numerous environmental issues, including noise contamination. Which level of importance would you rate the issue of noise contamination? Would you say that the issue of noise

contamination is not at all important, slightly, moderately, very, or extremely important for your visit? (CIRCLE ONE NUMBER)

1 Not at all important
2 Slightly important
3 Moderately important
4 Very important
5 Extremely important

10. Is there anything else you would like to tell us about your visit to (NAME OF PARK), including suggestions on lowering the audible noise in the park? (FILL IN BLANK)

____

____

____

PLEASE COMPLETE THE FOLLOWING BACKGROUND INFORMATION:

Sex: ________Male ________Female

What year were you born? 19____

Zip Code: ____________

THANK YOU FOR YOUR TIME AND PARTICIPATION.

Environmental Quality Board Contact Information:

Noise Control and Environmental Complaint Area

Environmental Quality Board (787-767-8181 ext 3115)

Sr. José A. Alicea Pou or Sra. Olga Viñas Curiel

Appendix D – Visitor Survey (Spanish)

Cuestionario Para el Visitante al Parque

Junta de Calidad Ambiental

Worcester Polytechnic Institute

Hola. Estoy ayudando La Junta de Calidad Ambiental con una encuesta de los visitantes de (PARK NAME. La información ofrecida por los visitantes ayudará a la Junta identificar cualquier problema en el parque y nos permitirá servirle mejor. Apreciaría unos minutos de su tiempo para contestar unas preguntas sobre su visita. Su participación en la encuesta es voluntaria y sus contestaciones son confidenciales y anónimas.

ESTE PRIMER GRUPO DE PREGUNTAS TRATA SOBRE SU VISITA AL PARQUE (NAME OF PARK.

1. ¿En qué fecha y a qué hora comenzó su visita al parque (NAME OF PARK)? (LLENE EL BLANCO)

   Fecha: Mes ____________________ Día: __________

   Hora: _____ _____: _____ _____ a.m./p.m.

2. ¿Es su primera visita al parque (NAME OF PARK) o ha visitado el parque antes? (CIRCULAR UN NUMERO)

   1 Primer visita → (PASAR A LA PREGUNTA 4)

   2 Visitó al parque antes

3. Si usted ha visitado el parque antes, incluyendo este viaje, ¿cuántas veces visitó (NAME OF PARK) en los pasados dos años? (LLENE EL BLANCO)

   __________ Cantidad total de visitas

4. En general, cuan agradable ha sido su visita a (NAME OF PARK. ¿Ha sido su visita no agradable, poco agradable, moderadamente agradable, bien agradable, o extremadamente agradable? (CIRCULAR UN NUMERO)

1 No agradable

2 Poco agradable

3 Moderadamente agradable

4 Bien agradable

5 Extremadamente agradable

5. ¿Cuan importante ha sido cada una de las siguientes razones para visitar (NAME OF PARK)? ¿Diría usted que cada razón es no importante, poco importante, moderadamente importante, bien importante, o extremadamente importante a su visita? (CIRCULAR UN NUMERO PARA CADA RAZON)

Diría usted que…	**No Importante**	**Poco Importante**	**Moderadamente Importante**	**Bien Importante**	**Extremadamente Importante**
ver la naturaleza es…	**1**	**2**	**3**	**4**	**5**
ejercitarse o caminar es…	**1**	**2**	**3**	**4**	**5**
disfrutar del silencio natural es…	**1**	**2**	**3**	**4**	**5**
Otra razón: _______ __________________ __________________	**1**	**2**	**3**	**4**	**5**

USTED PODRIA ESCUCHAR DISTINTOS SONIDOS NATURALES DURANTE SU VISITA COMO POR EJEMPLO ANIMALES, CORRIENTES DE AGUA, Y EL MOVIMIENTO DE LAS HOJAS EN EL VIENTO. OCACIONALMENTE, TAMBIEN PODRIA ESCUCHAR SONIDOS NO NATURALES EN (NOMBRE DEL PARQUE. ESTAS PROXIMAS PREGUNTAS TRATAN SOBRE LOS SONIDOS NO NATURALES EN (NOMBRE DEL PARQUE.

6. ¿Cuál sonido no natural, si alguno, esperaba usted escuchar durante su visita a (NOMBRE DEL PARQUE) antes de llegar?(CONTESTAR EN ESPACIOS EN BLANCO)

1 ________________________

2 ________________________

3 ________________________

4 **Ninguno**

7. ¿Cuál sonido no natural, si alguno, escucha usted durante su visita a (NOMBRE DEL PARQUE)? Favor de clasificar cada sonido como no molestoso, poco molestoso, moderadamente molestoso, bien molestoso, o extremadamente molestoso. (LLENE EL ESPACIO EN BLANCO Y CIRCULE ÉL NUMERO DQUE CORRESPONDA AL NIVEL DE MOLESTIA)

	No molestoso	**Poco molestoso**	**Moderadamente molestoso**	**Bien molestoso**	**Extremadamente molestoso**
____________________	**1**	**2**	**3**	**4**	**5**
____________________	**1**	**2**	**3**	**4**	**5**

____________________	**1**	**2**	**3**	**4**	**5**
____________________	**1**	**2**	**3**	**4**	**5**
____________________	**1**	**2**	**3**	**4**	**5**

8. Cuanta molestia ocasionó el ruido causado por sonidos no naturales en cada uno de los aspectos de su visita a (NOMBRE DEL PARQUE) El ruido causado por sonidos no naturales interfirió en el aspecto nada, poco moderadamente, mucho, extremadamente? (CIRCULEUN NUMERO PARA CADA ASPECTO MENCIONADO)

Diría usted que interfirió en…	**Nada**	**Poco**	**Moderadamente**	**Mucho**	**Extremadamente**
Disfrute del lugar…	**1**	**2**	**3**	**4**	**5**
Disfrute del ejercicio y/o caminata…	**1**	**2**	**3**	**4**	**5**
Apreciación del silencio natural del área…	**1**	**2**	**3**	**4**	**5**
Otro: _________ ____________________ ____________________	**1**	**2**	**3**	**4**	**5**

9. En Puerto Rico hay una serie de problemas ambientales incluyendo la contaminación de ruido. ¿Cuál es el nivel de importancia que usted le daría dicha contaminación? (CIRCULE UNAOPCION)

1 Ninguna importancia

2 Poco importante

3 Moderadamente importante

4 Bien importante

5 Extremadamente importante

10. Agradecemos sus sugerencias y comentarios sobre su visita y sobre este cuestionario, incluyendo sugerencias sobre como disminuir el nivel de ruido no natural.

____

____

____

POR FAVOR COMPLETE LA SIGUIENTE INFORMACION DEMOGRAFICA:

Sexo: ________Masculino ________Femenino

Año de nacimiento? 19____

Código Postal: ____________

GRACIAS POR SU TIEMPO Y PARTICIPACION.

JUNTA DE CALIDAD AMBIENTAL:

Area de control de Ruido y Querellas Ambientales

Junta de Calidad Ambiental (787-767-8181 ext 3115)

Sr. José A. Alicea Pou o Sra. Olga Viñas Curiel

Appendix E – Sample Noise Log

JUNTA DE CALIDAD AMBIENTAL
AREA CONTROL DE RUIDOS

RESERVE: Piñones **Coordenadas:**
Weather: Sunny, Clear, Breezy
Date: 4-20-2008 **Location:** Station 1
Device: Bruel & Kjear 2232 – 17020
Notes:

Hora	**dB(A)**	**Fuente Emisora**
1:59pm	47.8	Environmental Noise
2:03pm	74.1	Bikers
2:04pm	50.7	Car horn
2:06pm	76.5	Airplane
2:08pm	58.1	Motorcycle
2:08pm	72.8	Airplane and Bikers simultaneously
2:09pm	62.3	Man walking bike
2:09pm	63.0	Airplane
2:14pm	63.8	Airplane
2:14pm	53.6	Motorcycle or a car
2:15pm	62.3	Airplane
2:17pm	63.9	Airplane
2:19pm	79.8	Airplane
2:20pm	64.0	Bikers
2:21pm	51.4	People yelling far off

JUNTA DE CALIDAD AMBIENTAL
AREA CONTROL DE RUIDOS

RESERVE: Piñones
Weather: Sunny, Clear, Breezy
Date: 4-20-2008
Device: Bruel & Kjear 2232 – 17020
Notes:

Coordenadas: Ashley y Christina

Location: 1

Hora	dB(A)	Fuente Emisora
2:21pm	56.1	Scooter or Motorcycle
2:21pm	72.3	Airplane
2:22pm	62.6	Small airplane
2:24pm	61.3	Biker
2:25pm	53.7	Motorcycle
2:29pm	END	
______	______	______________________
______	______	______________________
______	______	______________________
______	______	______________________
______	______	______________________
______	______	______________________
______	______	______________________

Appendix F – Information about Piñones

Piñones Natural Reserve is located east of the Luis Muñoz Marin International Airport and Isle Verde on the Northeast coast of Puerto Rico, right alongside Route 187. This proximity to the highway and airport is cause for the large amount of traffic and aircraft noise. For those who visit the reserve, there is 6.8 miles of boardwalk that run through the forest, which is ideal for walking or biking. Many locals and tourists alike use this area for exercise.

The ecosystem of the reserve is classified as a sub-tropical moist forest and is one of the largest sites of mangrove forest throughout the island. The four different species of mangroves that grow in Piñones are the Buttonwood Mangrove, White Mangrove, Red Mangrove, and Black Mangrove. Because Piñones natural reserve is located at the coast, it is also home to the nesting sites of leatherback sea turtles, along with many native and migratory birds. The varieties of flora and fauna species are yet another reason why people visit Piñones natural reserve.

The project team observed that Piñones Natural Reserve was greatly affected by noise from the bordering Route 187 and the closeness of the Luis Munoz Marin International Airport. Because the mangrove trees do not grow very tall, they did not block out any of the external noises. Across Route 187 is a popular beach visited by many locals, especially on Sundays. The extensive crowd of people on the beach, along with their radios, added to the amount of noise generated. The boardwalk within the reserve, though a nice place for exercisers, was not visited as often as the beach across the road.

Appendix G – Information about El Yunque

El Yunque National Forest, also called the Caribbean National Forest, is the only tropical rainforest in the U.S. National Forest System. Annually, the forest receives anywhere between fifty to two hundred fifty inches of rainfall depending on the elevation. It covers 28,000 acres including the vast Luquillo Mountain Range. Known for its vast biodiversity, there are over a thousand different species of plants and hundreds small animals in the forest. Natively it is home to the Puerto Rico Boa, the Coqui frog, and the Puerto Rican Parrot.

El Yunque is visited by more than half a million people each year. There are 24 miles of trails available for hiking and two different lookout towers. The Yokahu tower is accessible by driving but the Mt. Britton tower can only be accessed by hiking the trails. The difficulty of the trails differs greatly, with some of the more strenuous trails near the top of the mountains. The map below shows several of the most commonly traveled trails.

The project team observed that Route 191 traveled through El Yunque National Forest, allowing cars to pass by trailheads within a few feet. This proximity is cause for much of the traffic noise heard by visitors. After the project team followed some of the trails, the traffic noise disappeared behind the loudness of the waterfalls and the natural sound barrier created by the trees. The trees also provided a sound barrier against aircraft noise. However, due to tour groups and other visitors, noise from people was often heard within the trails of El Yunque.

Appendix H – Information about Humacao

Humacao Natural Reserve is located on the southeast coast of Puerto Rico near Humacao and Naguabo. Totaling approximately 3,000 acres, it has been managed by the Department of Natural and Environmental Resources since 1984. It has several areas for hiking, biking, and kayaking, as well as a beach and picnic area. It is mostly visited by local fisherman during the week because it is an area rich in crabs and fish. The weekends are more popular for tourist activities like the kayaking that is offered.

The vicinity originated as a lagoon and was then drained to be used for sugar cane production in the 1930's. After a Hurricane David in 1979, the area flooded and is once again full of lagoons and forest. The commonly visited areas of the reserve are populated by over thirty species of birds as well as many iguanas. The bird sanctuary nearby has over ninety species of birds, leading the Humacao Nature Reserve to be one of the more popular bird watching sites. Several species of ducks, herons, and egrets are abundant. The beach bordering the reserve is a nesting place for three endangered species of turtles.

The ecosystem of the natural reserve is classified as sub-tropical and is made up mainly Pterocarpus forest along with the lagoons and estuaries. Annually the reserve receives 88 inches of precipitation on average. In the center of one of the lagoons, there is Monkey Island, named for the monkeys that inhabit it. However, it has been recommended that visitors do not go to the island because the monkeys have been known to be quite violent.

The project team noted that although Humacao Natural Reserve borders Route 3, only official vehicles are allowed within the reserve itself. There is a parking lot at the entrance of the reserve to limit the amount of traffic noise. At the far end of the reserve, the waves from the Caribbean Sea drown out a lot of the external noises. Due to many open spaces, such as the lagoons, aircraft noise could be easily distinguished. Most of the visitors to the reserve were locals and did not create a significant amount of noise unless they were fishing for crabs. On a good note, many of the visitors felt that the reserve was quiet and relaxing.

Appendix I – Information about Monagas

Julio Enrique Monagas Park is located in Bayamon, just west of San Juan, Puerto Rico. It can be characterized as an urban park, featuring a playground, picnic area, and horse stable. More popular on the weekends, equestrians can also be found practicing during the weekdays. There are several paths throughout the park, avidly utilized by bicycle enthusiasts and hikers. On the top of the hill within the park, there is a large observational tower. From the tower, Old San Juan and the Condado can be observed on a clear day. Another path to the side of the observational tower leads to a cliffside and cave that are often visited by those who wish to rappel.

The large amount of trees within the park tends to block out traffic noise from the highway, but a road travelling through the park to the horse stable creates closer auto noise. Most of the “people” noise comes from children visiting the park with their families. As for aircraft noise, it is not as noticeable in the main area of the park, but is very distinct at the observational tower.

Appendix J – Survey Responses by Age

One question on the survey inquired about the date of birth of the visitor in order to separate the participants into groups by age. The project group separated the participants into groups by age of twenty years or less, twenty-one through thirty years, thirty-one through forty years, forty-one through fifty, and fifty or more years. Figures 36 and 37 show the levels of importance and interference of the main park activities depending on the age of the visitor. It can be seen in the graph that the age group with the highest level of importance for exercising in parks were the participants who were thirty-one through forty years of age. The level of importance for exercising in the thirty-one through forty years old age group, 4.47, was slightly higher than that of any other age groups, 4.13, 4.0, 4.0 and 3.8. Another interesting tendency was the thirty-one through forty age group had one of the highest levels of importance for each of the activities. Also shown in the data, is a trend of increasing amounts of interference as the participants become older. An example of this increase is the levels of interference for experiencing the natural scenery. The less than twenty year old group has a level of 1.59, while twenty-one through thirty has a level of 2.33, thirty-one through forty has a level of 2.63, forty-one through fifty has a level of 2.59 and above fifty has a level of only 2.92.

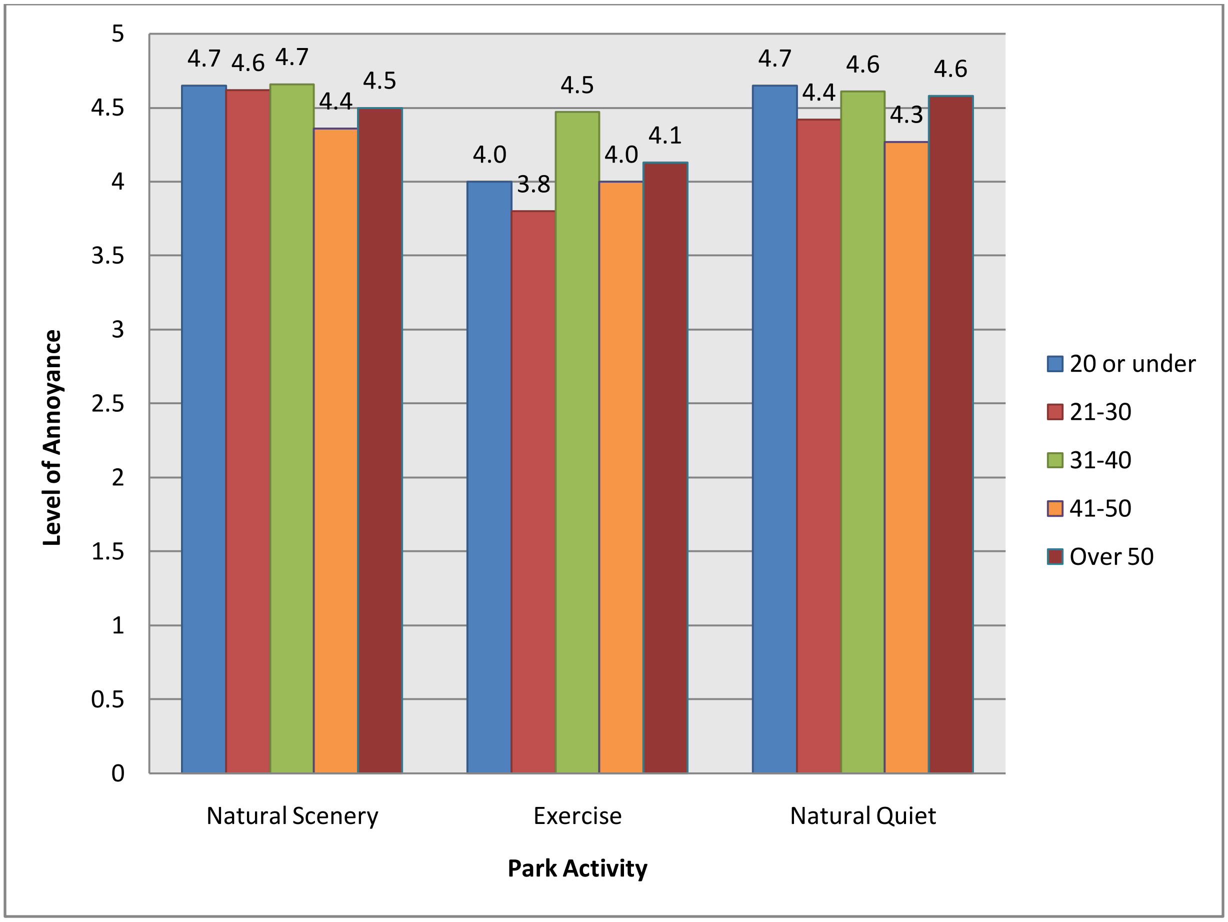

Figure 36 - Importance of Main Park Activities by Age (n=184)

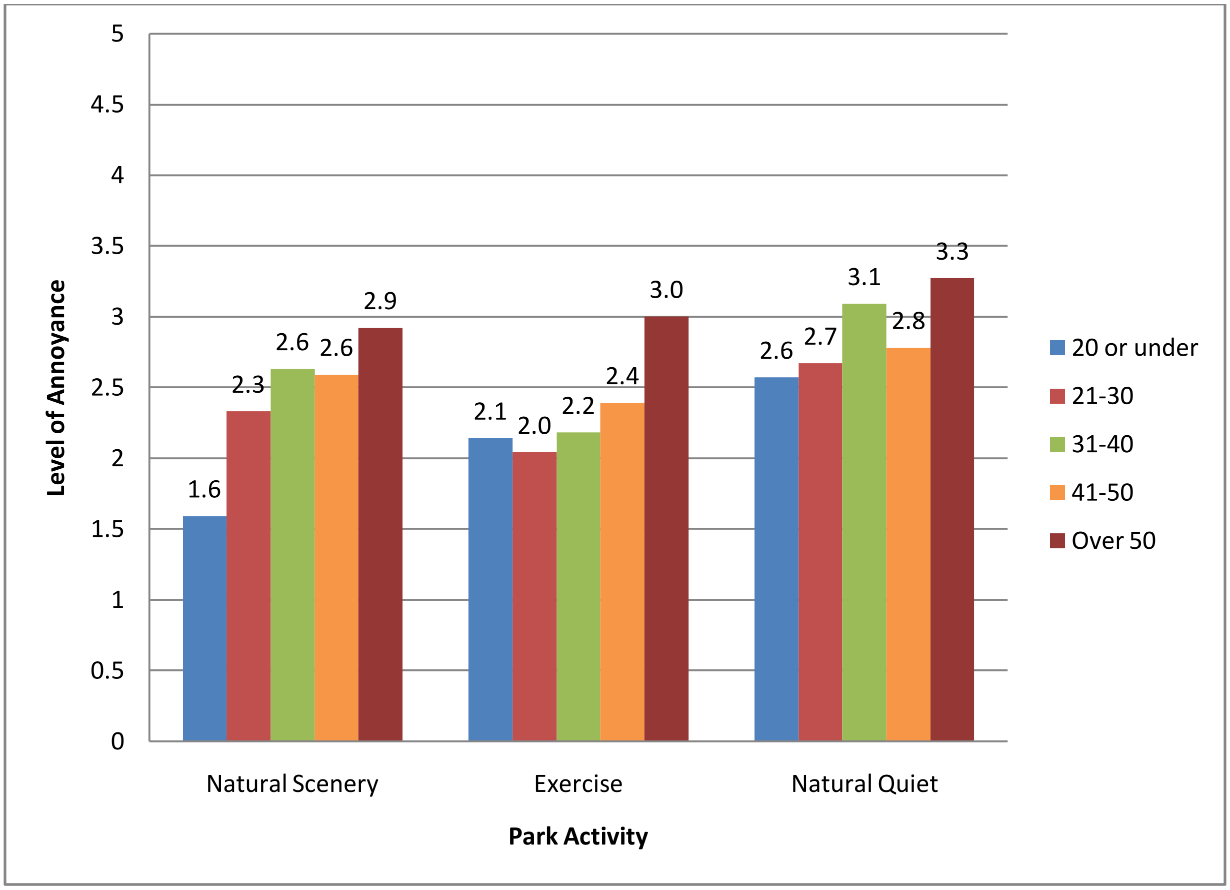

Figure 37 - Noise Interference of Main Park Activities by Age (n=184)

Appendix K – Survey Responses by Gender

One variable the project team separated park visitors by was gender. This allowed the team to determine whether there was a difference or not in how males and females responded to the questionnaire. Figures 38 and 39 show the level of importance and interference of the mentioned park activities by gender. The importance levels for viewing the natural scenery and exercising are similar for both genders, while men place greater importance on the natural quiet by 0.88. It is interesting to notice the trends for levels of interference between the two genders. For all three park activities, the level of interference for females is less than the interference levels for males. This is shown by a difference in interference level for females compared to males of 0.6 for viewing the natural scenery, 0.5 for exercising and 0.33 enjoying the natural quiet.

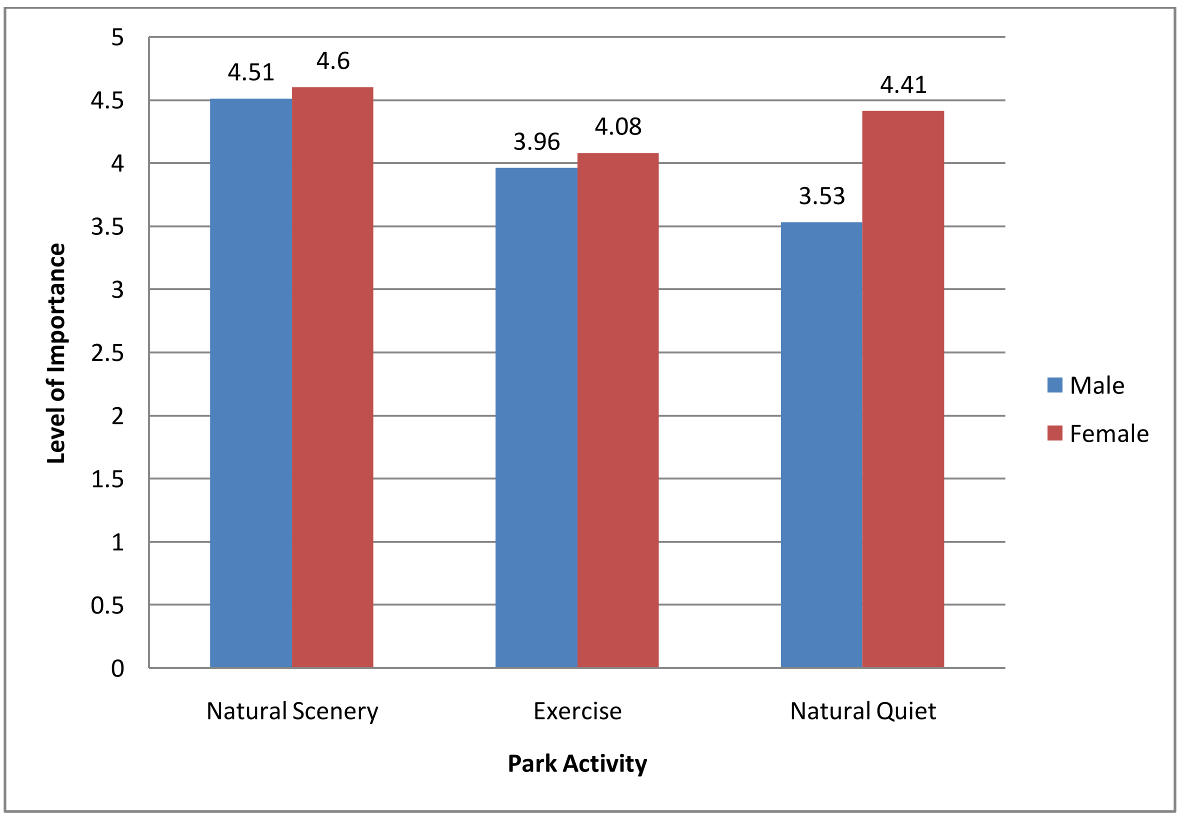

Figure 38 - Importance of Main Park Activities by Gender (n=201)

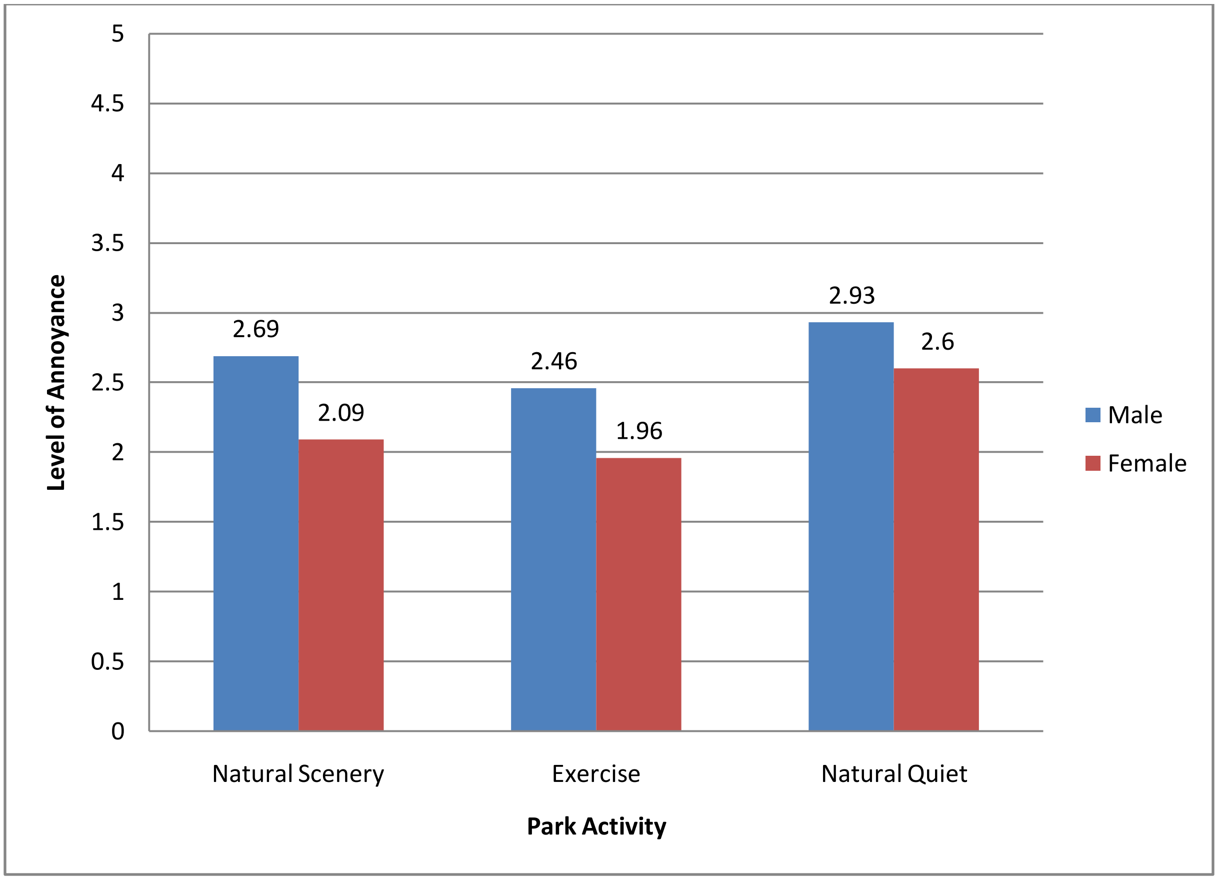

Figure 39 - Noise Interference of Main Park Activities by Gender (n=201)

Appendix L – Survey Responses by Residency

By reviewing the zip codes provided by the participants, the project team was able to separate respondents into groups of tourists and residents of Puerto Rico. Figures 40 and 41 show the data collected on the levels of importance and interference of main park activities by residency of the participant. The levels of importance are very interesting to compare between these two variables. It is shown that both the locals and the tourists feel that viewing the natural scenery and natural quiet are very important. There is not much difference between the two for these activities. The importance level for exercising is slightly different, however. For residents, the importance level for exercise is 4.23 while the importance level for exercise for tourists is only 3.77. This is expected because most tourists do not travel to exercise. This reason will explain why tourists feel natural scenery and natural quiet are the most important reasons for visiting a park. For both tourist and locals it is interesting to see that non-natural noises affected the natural quiet in the park more than anything, although there are still not very high interference levels. There is a very low level of interference with exercise, only 2.05 for tourists and 2.33 for locals, and a slight interference level for the viewing of the natural scenery, 2.31 for tourists and 2.53 for locals. There is not a lot of difference in interference for these two categories of tourists or residents.

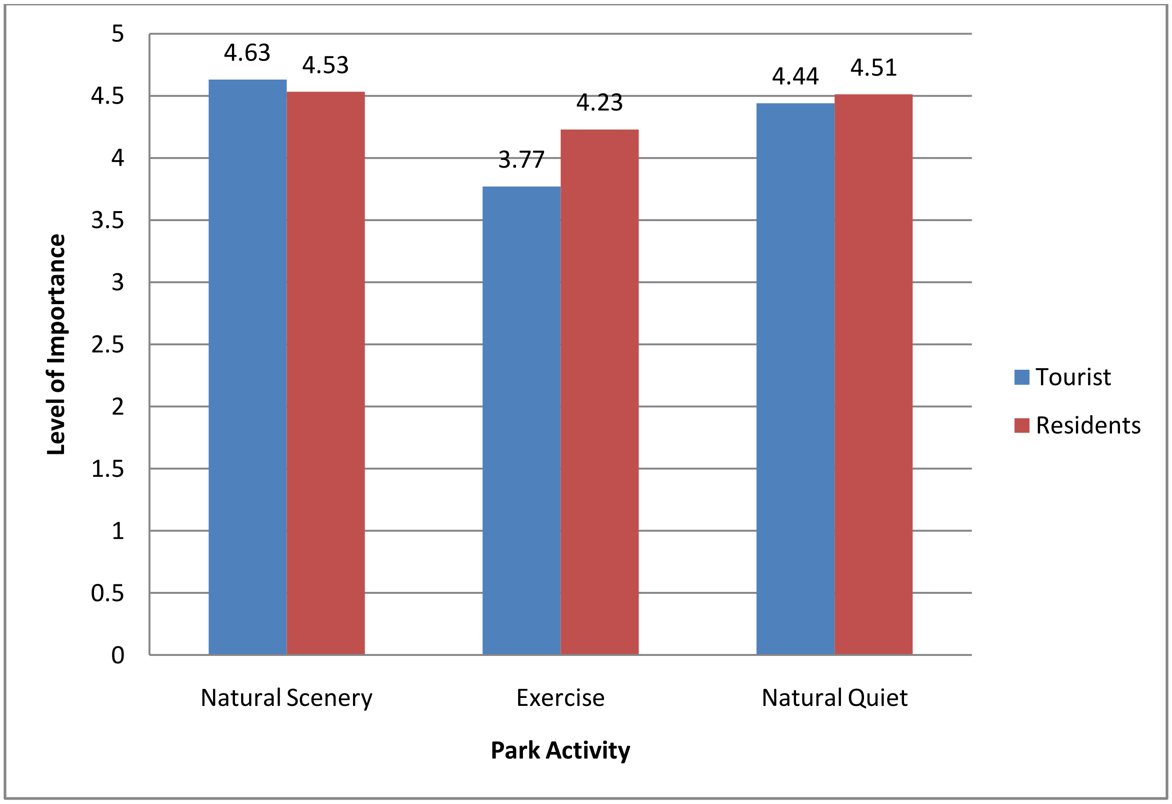

Figure 40 - Importance of Main Park Activities by Residency (n=192)

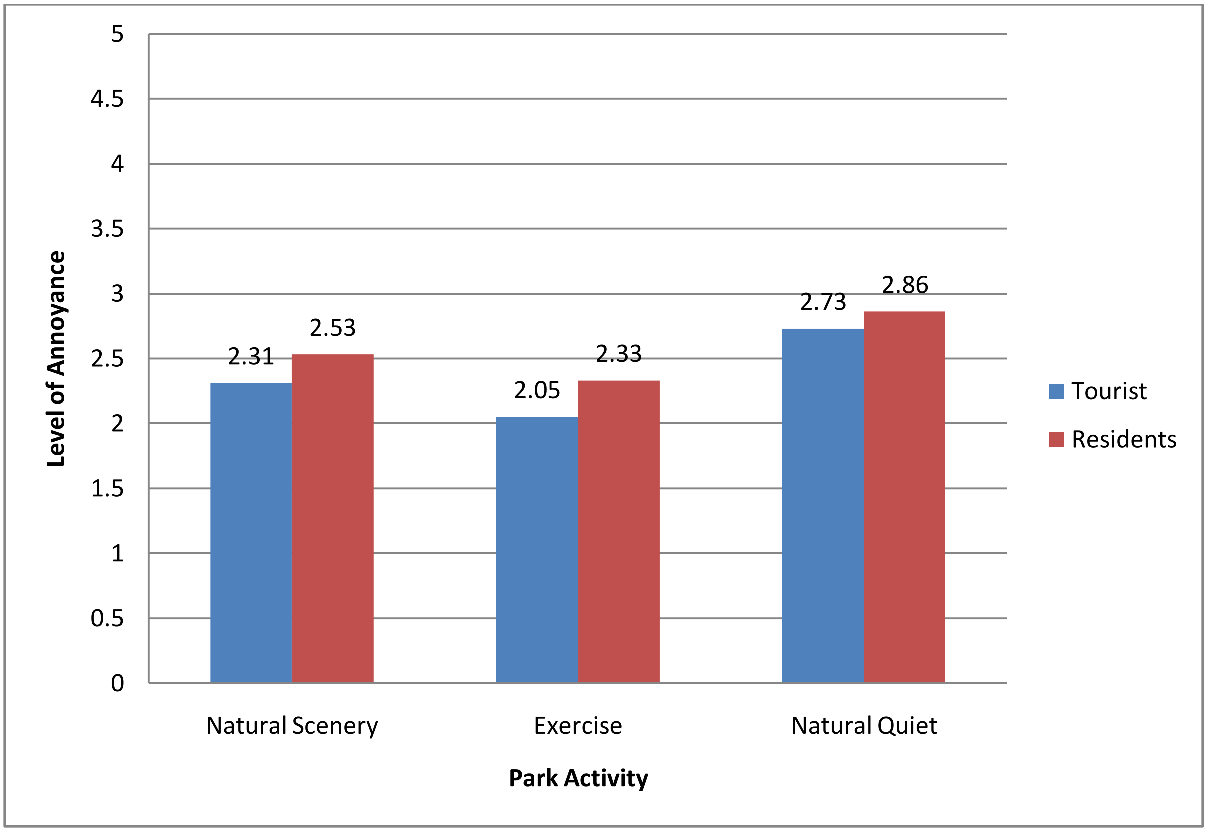

Figure 41 - Interference of Main Park Activities by Residency (n=192)

Appendix M – Survey Responses by Number of Visits

The questionnaire asked the participants about the number of times the visitor had been to the park of concern. Figures 42 and 43 show the levels of importance and interference separated by the number of visits each visitor had made to the park, including the visit the survey was completed. The importance levels for all number of visits are very similar, but the park visitors in the one to three visit categories consistently had the lowest level of importance. This trend is also consistent for the levels of interference. There is very little difference in the interference levels showing that the number of visits does not drastically affect the levels of importance and interference.

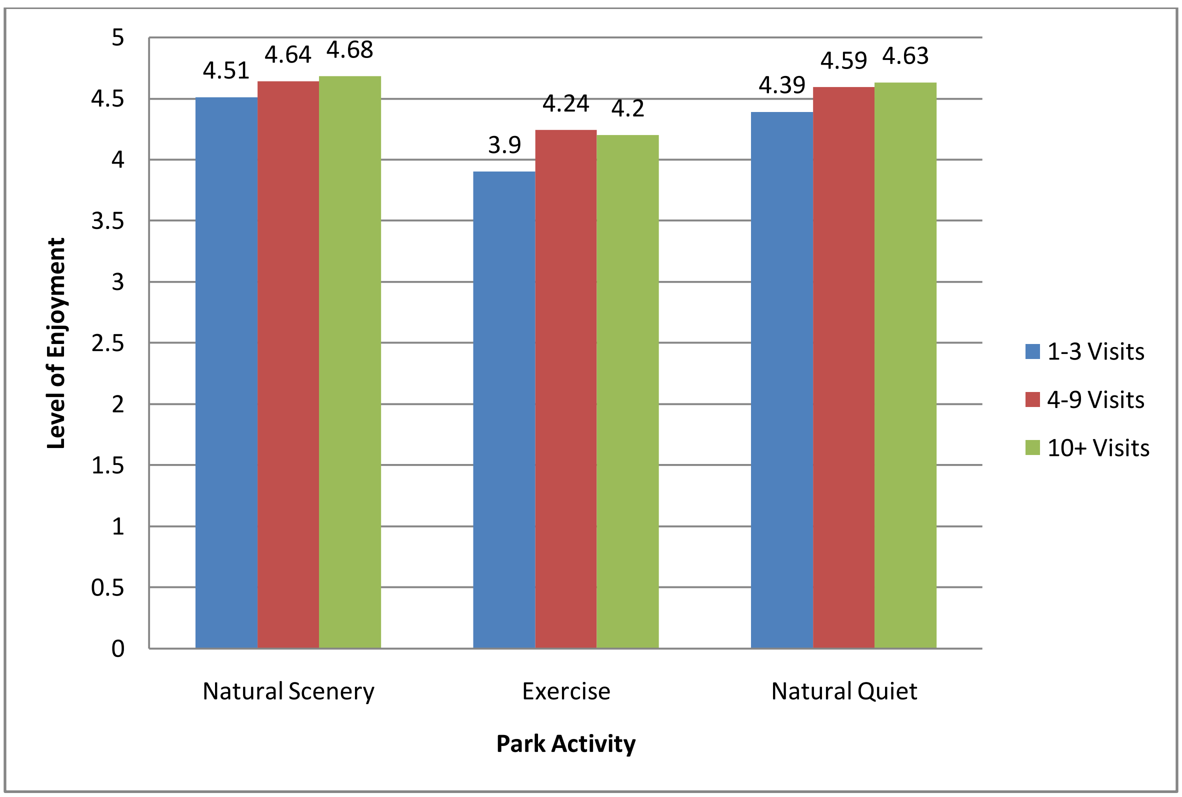

Figure 42 - Importance of Main Park Activities by Number of Visits (n=199)

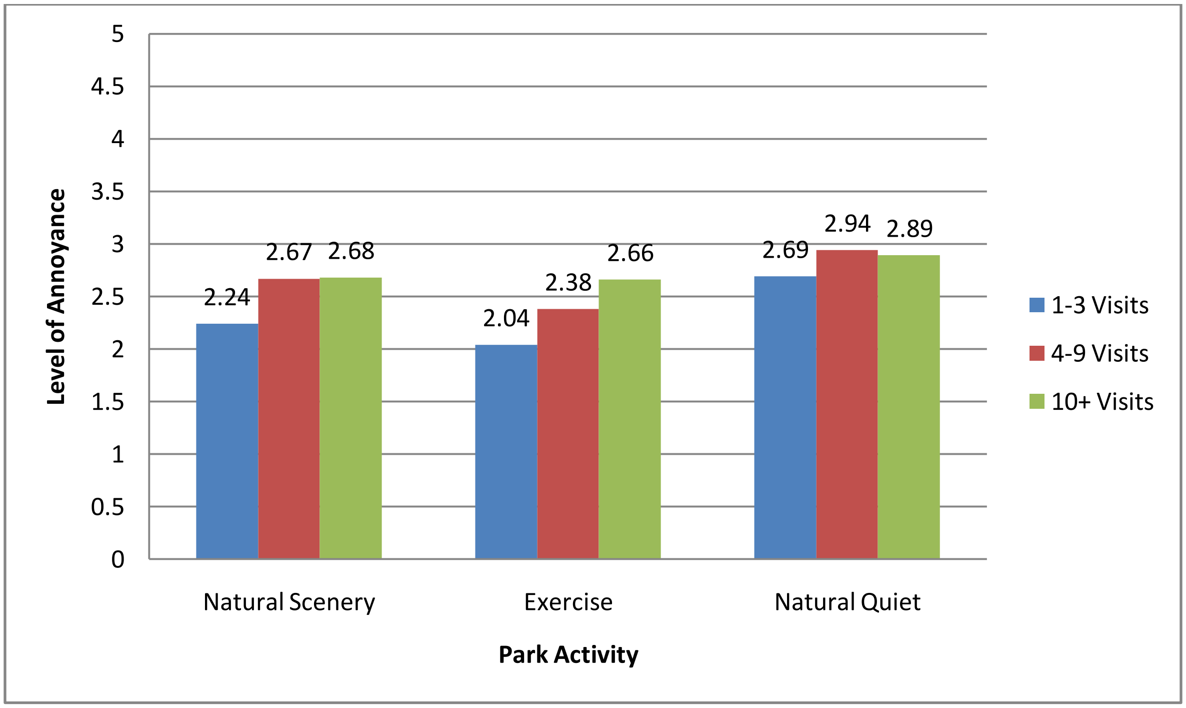

Figure 43 - Interference with Main Park Activities by Number of Visits (n=199)

Appendix N – ISO Standards for Surveying

TECHNICAL SPECIFICATION

ISO/TS 15666

First edition
2003-02-01

Acoustics — Assessment of noise annoyance by means of social and socio-acoustic surveys

Acoustique — Évaluation de la gêne causée par le bruit au moyen d'enquêtes sociales et d'enquêtes socio-acoustiques

Reference number
ISO/TS 15666:2003(E)

Contents

Page

Introduction

This Technical Specification is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the ISO Central Secretariat

Many countries have already developed regulations concerning the acceptability of environmental noise exposure, while others are likely to do so in the future Such regulations often take into account relationships between noise exposure and noise-induced annoyance.

Measurement of environmental noise has been standardized For example, ISO 1996 contains detailed specifications about basic quantities and procedures, about acquisition of (noise) data, and about the application of these data to set noise limits. ISO 3891 specifies measurements of aircraft noise heard on the ground. No International Standard yet recommends practices for measuring the prevalence of noise-induced annoyance, however.

The intent of this Technical Specification is to provide specifications for the assessment of noise annoyance by social and socio-acoustic surveys When these specifications are met, the statistically relevant possibilities of comparing and pooling survey results will be increased, thus offering more and better quality information for use by environmental policy makers.

Acoustics — Assessment of noise annoyance by means of social and socio-acoustic surveys

1 Scope

This Technical Specification provides specifications for socio-acoustic surveys and social surveys which include questions on noise effects (briefly referred to hereafter as "social surveys"). Its scope includes questions to be asked, response scales, key aspects of conducting the survey, and reporting the results. This Technical Specification does not prescribe methods for the analysis of data obtained from these questions.

It is recognized that specific requirements and protocols of some social and socio-acoustic studies may not permit the use of some or all of the present specifications. This Technical Specification in no way lessens the merit, value or validity of such research studies.

The scope of this Technical Specification is restricted to surveys conducted to obtain information about noise annoyance "at home". Surveys conducted to obtain information about noise annoyance in other situations, such as recreational areas, work environments and inside vehicles, are not included.

This Technical Specification concerns only the questions on noise annoyance used in a social survey and the most important additional specifications needed to accomplish a high level of comparability with other studies. Other elements which are required to provide high-quality social surveys, but which are not specific for social surveys on noise (such as sampling methods), can be found in textbooks (e.g. see references [1] and [2]).

Compliance with the recommendations of this Technical Specification does not guarantee the collection of accurate, precise or reliable information about the prevalence of noise-induced annoyance and its relationship to noise exposure. Other aspects of study design, as well as uncertainties of estimation and measurement of noise exposure, can influence the interpretability of survey findings to a great extent.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 1996-1, *Acoustics — Description and measurement of environmental noise — Part 1: Basic quantities and procedures*

ISO 1996-2, *Acoustics — Description and measurement of environmental noise — Part 2: Acquisition of data pertinent to land use*

ISO 1996-3, *Acoustics — Description and measurement of environmental noise — Part 3: Application to noise limits*

ISO 3891, *Acoustics — Procedure for describing aircraft noise heard on the ground*

5 Additional specifications for conducting social and socio-acoustic surveys when asking about noise annoyance

General specifications for conducting social surveys of any kind are found in numerous articles, papers and textbooks (e g references [1] and [2]). This clause does not give a comprehensive overview of these general specifications. The focus in this clause is on additional specifications with respect to the design of the questionnaire when asking about noise annoyance. More information is given in Annex A.

a) Each respondent shall be asked both questions specified in Clause 4. Respondents shall not be eliminated on the basis of some previous question about whether they "hear" the noise, nor on the basis of length of residence. If it is necessary to determine whether some respondents do not hear the noise source, a question about the audibility of the noise may be asked separately later in the interview

b) Respondents shall not first be asked if they are annoyed or not and then, if they are annoyed, about their degree of annoyance.

c) The questions shall be placed early in the questionnaire, unless this conflicts with other survey objectives, and before other, more detailed, questions about noise have been asked. If other questions on noise annoyance are more important for the survey's purposes, the specified questions may be asked later

d) When asking a question about annoyance, do not imply that the noise should be present in the respondent's situation at home. Ask, for instance, about "noise from aircraft" instead of "noise from the aircraft".

e) If pre-tests indicate that the questions are perceived as repetitious, include appropriate instructions. An example is presented in Annex A.

f) If show cards are used, the answer categories of the five-point verbal scale shall be presented without numbers, as follows:

CARD QV
NOT AT ALL
SLIGHTLY
MODERATELY
VERY
EXTREMELY

The show card for the numerical scale shall be as follows:

CARD QN										
NOT AT ALL									EXTREMELY	
0	1	2	3	4	5	6	7	8	9	10

The chosen answer shall be marked clearly within one box.

Table 1 — Minimum specifications for reporting core information from social and socio-acoustical surveys in scientific reports

Topic area	Item	Topic	Required information
Overall design	1	Survey date	Year and months of social survey
	2	Site location	Country and city of study sites
	3	Site selection	Any important, unusual characteristic of the study period or sites Map or description of study site locations relative to the noise source
	4	Site size	Rationale for site selection Site selection and exclusion criteria
	5	Study purpose	Number of study sites Number of respondents by site State original study goals
Social survey sample	6	Sample selection	Respondent sample selection method (probability, judgmental, etc.) Respondent exclusion criteria (age, gender, length of residence, etc.)
	7	Sample size and quality	Response rate Reasons for non-response
Social survey data collection	8	Survey methods	Method (face-to-face, telephone, etc.)
	9	Questionnaire wording	Exact wording by primary questionnaire items (including answer alternatives)
	10	Precision of sample estimate	Number of responses for main analyses
Acoustical conditions	11	Noise source	Type of primary noise source (aircraft, road traffic, etc.) Types of noise source operations that are included or excluded Protocols to define the noise source (e.g. minimum level, operations, days of week)
	12	Noise metrics	Give the complete description of any noise metric reported, according to ISO 1996-1, ISO 1996-2, ISO 1996-3 or ISO 3891 (if applicable): — Provide $L_{Aeq,24h}$, L_{dn} and L_{den} (or L_{Aeq} by time-period) for all locations or — provide conversion rule(s) to estimate $L_{Aeq,24h}$, L_{dn} and L_{den} under the specific study conditions from the study's preferred metric — Discuss the adequacy of the conversion rule(s) — Provide impulse and/or tone corrections
	13	Time period	Hours of day represented by noise metric Period (months, years) represented by noise metric
	14	Estimation/ measurement procedure	Estimation approach (modelling, measurement during sampled periods, etc.)
	15	Reference position	Nominal position relative to noise source and reflecting surfaces Present exposure (or give conversion rule) for noisiest façade, specifying whether reflections from the façade are taken into account or not
	16	Precision of noise estimate	Best information available on precision of noise exposure estimates
Basic dose/ response analysis	17	Dose/response relationships	Tabulation of frequency of annoyance ratings for each category of noise exposure

A.3 Noise, not sound

In many languages it is linguistically odd to use the word "sound" in relation to unwanted sound. In connection with unwanted sound usually the word "noise" is used

A.4 Unipolar scales (neutral-negative)

From many previous surveys, it has been found that reactions to transportation noise are overwhelmingly either negative or neutral. Therefore the questions should use unipolar scales that extend from a negative pole (extremely annoyed) to a neutral position (not at all annoyed), but not to a positive pole (extremely enjoyable).

A.5 Two questions

This Technical Specification recommends the use of two questions on annoyance and two annoyance scales in each questionnaire. Using more than one scale is consistent with the most basic principles of increasing the reliability of psychometric measurements

A.6 A verbal and a numerical scale

Each of the scales has a different strength. The verbal scale is needed for the clearest, most transparent communication. The simple task of choosing a word is most likely to be easily performed by respondents of any degree of sophistication in any culture. The resulting selected word is, when presented in a report, simply passed on to readers as the respondent's choice. The protocol used to choose the answer scale words attempts to ensure that the commonly understood meaning of the word is consistent with its position on the scale

The numerical scale is needed to provide a check on the consistency of the respondent's answer on an important issue. Furthermore, the numerical scale is useful as a second question that may not be as subject to the choice of words as a verbal scale is, which is an advantage in a multiracial society and in international work.

A.7 General, non-specific reaction questions

The recommended questions seek to obtain general, consistent reactions that allow respondents to integrate their experiences over different times and locations in and around their home (e.g. on a balcony, in a garden). They do not specify one particular combination of conditions because an overall response measure necessarily involves an integrated response over a range of different types of experiences. The questions do not explicitly list the range of conditions over which the experiences should be integrated for the following five reasons

a) A complete list would involve too many conditions (e.g. room in a home, location on property, season of year, day of week, hour of day, window-opening conditions, activity during exposure, number of noise events, and peak levels of noise events).

b) A long list may lead respondents toward objective assessments of noise exposure levels and away from subjective feelings about exposures.

c) A long, complex question may confuse some respondents who will resolve the complex task by just answering for one condition, perhaps the first or last condition mentioned, while ignoring their most important, but seemingly insufficiently sophisticated, feelings about their general subjective response.

d) A long list of conditions is more difficult to adapt to different cultures and languages.

e) A long question is less likely to be included in many surveys.

A.9 Choice of response descriptors in other languages than English

The translation of each question in each language should be performed by translation and back-translation. For languages other than English, the labels for the categories on the 5-point verbal scale and the endpoints for the 0-to-10 numerical scale should be chosen on the basis of empirical studies conducted using a standard technique in each language and not be simply translated from English. The studies should be conducted following the protocol presented in reference [5]. These types of study were actually carried out in the following nine languages: Dutch, English, French, German, Hungarian, Japanese, Norwegian, Spanish and Turkish. The questions and answer categories in these languages are presented in Annex B.

NOTE If an ISO Member Body doubts the correctness of the translations presented in Annex B, it should initiate a replicate study to improve the translations as they stand now. Just changing the wording based on personal preference instead of based on empirical studies does not seem a fruitful approach.

A.10 11-point numerical scale

The 0-to-10 scale was selected because it is assumed that a 0-to-10 scale would be more readily understood and manipulated than a shorter 7-point, 9-point or 10-point scale. Most people are familiar with base-10 numeric systems through currency and other familiar counted materials. Logically, 0 will always stand for "not at all", and 10 for "extremely". The scale should not be reversed.

As with all questions in a questionnaire, there needs to be a provision for coding missing data responses such as "don't know", "refusal" or "skipped in error". It is recommended that the survey organizations include a code for such answers.

CAUTION — These possible answers should not, however, be shown or read to respondents. They would not, therefore, appear in a mail questionnaire. One of the primary findings from question-wording experiments is that the number of don't knows is very much increased if the respondent sees or is offered this option.

Interviewers should use such a code only after having encouraged the respondent to choose one of the offered responses with a phrase, such as *"Which of the answers comes closest to your view?"*

A.11 5-point scale for verbal questions

For the purpose of comparisons between surveys, the same number of points are needed on all verbal answer scales. The discussion about the use of dichotomous answer scales clearly indicates that the number of scale points do have an effect on answers that cannot be accounted for by the labels that are used. In considering the evidence, it was decided that a 5-point scale is preferable. The available evidence suggests that a 5-point scale is either preferable or no different than the 4-point scale. See also reference [5].

Also, the 5-point verbal scale must be completed with "don't know" as an answer alternative. See also A.10.

A.12 Appropriate time period

The phrase "12 months or so" appears in parentheses in the questions because the length of the time period may need to be different for different surveys. The period that is asked about in the questionnaire should be a period for which the noise exposure can be estimated sufficiently accurately. In general, a period of approximately one year is recommended to encourage respondents to give their general reactions to the acoustical environment. However, if there have been recent changes in the noise environment, or if the focus of the study is on a particular time, or if is it not possible to make sufficiently accurate estimates for a long time period, then some shorter period may need to be specified.

A.14.3 If pretests indicate that the questions are perceived as repetitious

If the questions are not placed early in the questionnaire, potential interviewer or respondent discomfort with apparently repetitious questions can be solved with introductions to the questions similar to the following.

a) *Now we return to the noise from (source) and take everything we have discussed into account. Thinking about the last* ... {insert recommended questions}.

b) *People in other surveys have answered this next question to tell us how they feel about noise. Now you can use it for the noise here. Thinking about the last...* {insert recommended questions}.

c) *Even though all of the questions are slightly different, I know a few of them can seem similar for people in special circumstances like yourself. If any seem repetitious for you, just give me a quick answer and I will move right along to other questions.*

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Appendix O – Data Coding Spreadsheet

This is an example of the data spreadsheet used for the survey database.

Appendix P - Timeline