DISSERTATION

SOURCE ATTRIBUTION OF HELICOPTER NOISE IN PRISTINE ENVIRONMENTS

Submitted by

Britton Lee Mace

Department of Psychology

In partial fulfillment of the requirements

for the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Summer, 1999

UMI Number: 9947951

Bell & Howell Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

COLORADO STATE UNIVERSITY

July 12, 1999

WE HEREBY RECOMMEND THAT THE DISSERTATION PREPARED UNDER OUR SUPERVISION BY BRITTON LEE MACE ENTITLED SOURCE ATTRIBUTION OF HELICOPTER NOISE IN PRISTINE ENVIRONMENTS BE ACCEPTED AS FULFILLING IN PART THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

Committee on Graduate Work

Co-advisor

Co-advisor

Department Head

ABSTRACT OF DISSERTATION

SOURCE ATTRIBUTION OF HELICOPTER

NOISE IN PRISTINE ENVIRONMENTS

Helicopter noise has increased dramatically throughout the remaining natural areas of the United States during the past two decades. Federal legislation has been established (National Parks Overflight Acts, 1987, 1997) in order to establish regulations in areas affected by aircraft overflights. Before regulations can be adopted and enforced, however, management alternatives need to be identified and studied. Unfortunately, a limited amount of research has been completed directly examining noise issues in natural environments.

Mace, Bell, and Loomis (1999) simulated conditions in the Grand Canyon in order to study the effects of helicopter noise on aesthetic, affective, and cognitive measures in the laboratory. Results indicated that helicopter noise at both a 40 dB(A) and an 80 dB(A) level had a significant effect on landscape ratings of preference, scenic beauty, annoyance, solitude, tranquility, freedom, and naturalness. Furthermore, affect was significantly more negative following exposure to helicopter noise.

There is some evidence that individuals will tolerate, or even be pleased with, loud mechanical noise if the noise signals that rescue is on the way or that the noise contains some type of value to the individual (Anderson, Mulligan, Goodman, & Regen, 1983; Kariel, 1990). Attribution theory suggests that the source of the noise may be a major moderator of these effects. Specifically, in the present study it was hypothesized that helicopter noise attributed to tourist operations would have a stronger negative effect on ratings of annoyance, preference, naturalness, scenic beauty, solitude, tranquility, and freedom than noise attributed to a Park Service rescue flight or a Park Service flight for remote trail maintenance. Similarly, noise attributed to helicopter tourist operations was also expected to significantly impact positive and negative affect. Based on previous research showing that intermittent and uncontrollable noise exposure does not habituate (Fields, 1990; Griffiths, 1983; Weinstein, 1982), all noise conditions in this study were expected to yield more unfavorable ratings than a nature sound control group.

Two hundred university students (106 women and 94 men) completing a research requirement or earning extra credit in a psychology course served as participants in one of four completely between-subjects conditions. Participants rated 30 natural landscapes on level of annoyance, naturalness, scenic beauty, freedom, solitude, tranquility, and overall preference while being exposed to either nature sounds or helicopter noise. Measures of positive and negative affect were also obtained in a pre-post design.

Multivariate analyses of variance found that helicopter noise, regardless of its source, had a significant negative effect on all landscape rating scales. Furthermore, the negative effects produced by the helicopter noise, whatever its source, were consistent in all natural environments (mountain peaks, water, forests, deserts, etc.) depicted in this study. Exposure to helicopter noise, whatever the source, also caused a significant reduction in positive affect.

Results were interpreted as providing evidence that the mere presence of helicopter noise triggers important reactions, whether the source of the noise is attributed to a tourist overflight, a Park Service rescue flight, or a Park Service backcountry trail maintenance flight. These findings suggest that natural ambient sounds are important and

should be taken into consideration when landscapes are being evaluated or when land management decisions are being made.

Britton Lee Mace
Department of Psychology
Colorado State University
Fort Collins, Colorado 80523
Summer, 1999

TABLE OF CONTENTS

LIST OF TABLES

Table	Page

LIST OF FIGURES

Chapter I

Introduction

In the United States, legislation has been enacted by Congress in order to preserve and protect natural land areas and the unique natural resources they contain. The Yellowstone Act (1872) created the first federally protected "public park or pleasuring ground." This legislative achievement proscribed the Yellowstone area and its inherent resources to be preserved in their natural condition. The National Park Service Act (1916) established the National Park System as a government agency to oversee, protect, and manage units of the newly established park system. After nearly a century of discussion, debate and patriotic public support (Asleson & Moore, 1985) a federal land preservation system was born.

The National Wilderness Preservation Act (1964) furthered the land preservation mentality by classifying tracts of natural land areas 6000 acres and larger as Class I Wilderness Areas. According to the Wilderness Act, Class I Areas are to retain their "primeval character" and be protected in a manner that ensures "the earth and its community of life are untrammeled by man." Yet, it took the Environmental Policy Act of 1969 to expand the circle of legislative environmental concerns to include such important resources as visibility, natural scenic beauty, and the overall wilderness experience (Daniel, 1990). Many of the research questions spawned from such legislative acts are dependent on psychological methodology. Most of this research has the advantages of making theoretical contributions while also addressing real-world issues and providing useful information to federal decision makers and land managers.

With the passage of the National Parks Overflights Act of 1987, the issue of aircraft overflights has captured attention from congressional leaders, federal land managers, the National Park Service, the Forest Service, the Bureau of Land Management, the Federal Aviation Administration, municipalities and counties, developers, home owners, and business interests in the United States. Given the multiplicity of interests involved in the issue, it is easy to recognize why research has rapidly accelerated during recent years. Under this federal mandate, a number of federal land managing agencies were instructed to submit reports to Congress detailing the impacts overflights have on national parks and wilderness areas. This requirement has subsequently led to a number of research projects examining the many facets involved with aircraft overflights.

Mace, Bell, and Loomis (1999) simulated real world conditions in the Grand Canyon in order to study the effects of helicopter noise on aesthetic, affective, and cognitive measures in the laboratory. Results indicated that helicopter noise at both a 40 dB(A) and an 80 dB(A) level had a significant effect on landscape ratings of preference, scenic beauty, annoyance, solitude, tranquility, freedom, and naturalness. Furthermore, affect was significantly more negative following exposure to helicopter noise. Results suggest that helicopter noise interferes with the quality of the visitor experience, and even affects the perceived aesthetic quality of natural landscapes.

When the findings from studies in natural environments are viewed in relation to past research examining noise in urban settings, it becomes evident that the results may be analogous to the effects produced by noise in the built environment (for a review see Kryter, 1985; Staples, 1996). In fact, when considering that people are visiting natural areas to escape the stressors found in the city, experience solitude and tranquility (Driver, Nash, & Haas, 1987), restore themselves from daily stressors (Ulrich, 1993), and to enjoy nature (Driver, Tinsley, & Manfredo, 1991), the psychological effects of transportation noise may be even more pronounced in natural environments. This becomes especially important when considering the rapid increase and spread of human-produced noise throughout the parks and wilderness areas of the United States. Escape from this ambient environmental stressor then becomes more and more difficult.

The present study examined helicopter noise in a variety of natural landscapes, including the Grand Canyon simulated in a laboratory, and manipulated source attribution of the helicopter noise. There is some evidence that individuals will tolerate, or even be pleased with, loud mechanical noise if the noise signals that rescue is on the way or that the noise contains some type of value to the individual (Anderson, Mulligan, Goodman, & Regen, 1983; Kariel, 1990). For this reason, it was believed that helicopter noise attributed to a National Park Service (NPS) rescue flight would be deemed significantly less annoying than helicopter noise attributed to a tourist flight. In a third condition, noise was attributed to a helicopter assisting with maintenance on a remote trail, and in a control condition, no helicopter noise was present. It was expected that the noise attributed to the tourist flight would be the most annoying and also result in significant reductions in landscape aesthetics, perceived environmental quality, and affective state.

Noise Encounters in Natural Environments

Noise is produced primarily by human endeavors, and, therefore, typically occurs in environments subjected to human activities. For this reason, most research examining noise has been focused within human-dominated environments. However, noise, like haze, is no longer limited to urban areas. The byproducts of an industrial life-style have spread noise throughout the parks and wilderness areas of the country and world, emanating from such sources as automobiles, aircraft, snowmobiles and watercraft. With the increasing frequency of noise encounters in natural environments, research has focused attention on these events and their effects on human and non-human behavior.

While a considerable amount of research has examined the effects of noise on health, performance, and human behavior in a variety of urban and built settings, no extensive study has focused specifically on the effects of noise in natural environments (Kariel, 1990). For that matter, relatively few studies have dealt with noise issues within natural environments in the broad sense, either. In general, research has found that prolonged exposure to noise in the home or workplace is associated with a multitude of health problems, including hearing loss (Alexander, 1968; Lebo & Oliphant, 1968), high blood pressure, and strokes (Cameron, Robertson, & Zaks, 1972; Cohen, Evans, Krantz, Stokols, & Kelly, 1981; Cohen & Weinstein, 1980; Dellinger, 1979; Peterson, Augenstein, Tanis, & Augenstein, 1981). Although the studies examining the health effects of transportation noise are primarily correlational, the research to date suggests a relationship between health and those who are bothered by aircraft, railroad, or highway noise (Bronzcraft, Ahern, McGinn, O'Connor, & Savino, 1998; Fay, 1991; Health Council of the Netherlands, 1994; Kryter, 1994; Passchier-Vermeer, 1993; Tempest

1985). Specifically, these studies indicate that noise may play a significant role in such ailments as hypertension and cardiovascular disorders, sleeping difficulties, and gastrointestinal problems. Furthermore, many researchers argue that the stress-related effects of community noise have been significantly underestimated since annoyance does not habituate (Fields, 1990; Griffiths, 1983; Weinstein, 1982). Long-term exposure to aircraft noise may also have mental health consequences (Abey-Wickrama, a'Brook, Gattoni, & Herridge, 1969; Herridge & Chir, 1972). If noise exposure has a negative effect on human well-being in urban areas, the question then arises as to the potential effects in a natural environment.

One of the major criticisms of landscape assessments has been the lack of multi-sensory stimuli being presented to participants during the simulation. Sounds are obviously an important component of any nature experience and should thus be included in landscape evaluations whenever conditions allow. Furthermore, with the continuing spread of ambient auditory stressors into these natural areas, research regarding their physical and psychological effects becomes even more critical. Because of the limited number of landscape assessments incorporating noise into the research design, contributions from other disciplines employing differing methodologies have thankfully appeared to cast light on this complex issue.

Federal land managers are concerned with the multiple-use mandate of their governing agencies, and consequently have been one of the few entities that have explored the effects of noise within wilderness and recreational contexts. The United States Forest Service of the Department of Agriculture has studied the effects of noise from such mechanically driven devices as motorcycles, all-terrain vehicles, and snowmobiles on different types of forest visitors. The results of these studies have been summarized by Harrison (1974), and show differences in noise perception between the operators of these devices, "by-standers," and "other" forest recreationists. Kariel (1990) found significant differences between mountaineers and other recreationists in their perception of and annoyance with motor-driven noises. Mountaineers were found to be significantly more annoyed with all sounds emanating from a motorized device, including aircraft (Kariel, 1990). No differences between recreational groups have been found when evaluating natural ambient conditions or nature-related sounds.

To further investigate the recreational motives of forest visitors, Harrison, Clark, and Stankey (1980), using the Outdoor Recreation Opportunity Spectrum (Driver & Brown, 1978), discussed the unacceptability of noise in Forest Service recreation areas across different visitor groups. However, as with the review compiled by Harrison (1974), the research suffered from a variety of control and methodology issues, and only spoke of noise exposure produced by mechanically driven devices in general terms.

Dellora, Martin, and Saunders (1984) synthesized their laboratory studies of conflicts between four-wheel drive users, hikers, picnickers, and other recreationists in Victoria, Australia. These researchers found that motorcycle noise at sound levels greater than 68 dB(A) was the main cause of recreational conflicts. However, noise produced at sound levels lower than 68 dB(A) was not taken into consideration in this study.

Kariel (1990) obtained data from three Canadian national parks via survey in highway-oriented campgrounds. Participants were asked to rate a variety of technological and natural sounds commonly present in the area using a five-point bipolar scale measuring pleasantness and annoyance. Rank-order results indicated the top eight annoying noises to be technological in origin, with chainsaws, motorized trail bikes, and car noises the most annoying. Aircraft noise was rated as the sixth most annoying noise in this study. Kariel's results indicated that the level of human- and technology-related sounds should be kept generally low (below the background level of about 15 dB(A)) in outdoor recreation-type environments. Kariel (p. 148) concluded "it would also be desirable to restrict or regulate the use of sound-producing items, such as aircraft overflights, snowmobiles, generators, motorboats, and radios, in order to safeguard a recreational milieu." Given the multiple-use mandate of the federal land administrators in the United States and the variety of recreational motives brought to these areas by visitors, the results of this study are particularly compelling.

Aircraft Overflights in Natural Environments

In order to assess the frequency of aircraft overflights, among other issues, Tabachnick, Howe, and Fidell (1992) examined all types of aircraft overflight exposure in national parks and wilderness areas. This research produced a rank order of commercial helicopter sightseeing tour services flying in and around the national parks and wilderness areas of the country. Grand Canyon ranked highest, with 36 independent tour operators providing sightseeing helicopter rides through the canyon. The next highest rankings included Haleakala (12 operators) and Volcanoes National Park (8), both located in Hawaii. In these parks aircraft noise has become nearly inescapable with sightseeing aircraft increasing to 10,000 a month in the Grand Canyon and 60 aircraft a day at Hawaii Volcanoes (Staples, 1996). Numbers of complaints at these parks are equal to those commonly received at busy urban airports (Lee, 1994). Although these three parks are affected significantly more than any other park or wilderness areas studied thus far, this does not mean that other areas are not prone to aircraft tour operations. In fact, it is estimated that over 150 units of the national park system are routinely exposed to the noise of aircraft overflights.

The National Parks Overflight Act (Public Law 100-91) requires the National Park Service and the U.S. Forest Service to identify "acceptable levels" of aircraft overflights in federal Class I wilderness areas. Consequently, some research has measured ambient conditions in a variety of locations throughout those pristine environments which have been identified as overly affected areas. Horonjeff, Kimura, Miller, Robert, Rossano, and Sanchez (1993) sought to provide baseline information about the intensity and duration of aircraft noise in Grand Canyon, Haleakala, and Hawaii Volcanoes National Parks. Measurements were obtained at 23 separate locations within Grand Canyon National Park, many of which were designated as no-flight zones due to regulations put into effect by way of Special Federal Aviation Regulation 50-2. Results from this study found aircraft sound levels as high as 76 dB(A) in Grand Canyon. In some areas of Grand Canyon, aircraft noise is audible 79 percent of the time, with as many as 43 separate aircraft noise events occurring within every 20-minute interval. Helicopter tours in the Grand Canyon have increased from 40,000 in 1987 to 95,000 in 1996 (Kanamine, 1997). On the busiest days, up to 100 helicopters may be in the airspace above the Grand Canyon at any give time. Furthermore, a number of the measured locations in the Grand Canyon produced interesting echo phenomena, where it was possible for a single aircraft to sound as if 3 or 4 separate aircraft were present, even without the aircraft being visible. The results show not a single location recorded in Grand Canyon National Park to be totally free of aircraft noise, especially when considering the noise can echo for up to 16 miles along the inner walls of the canyon (Kanamine, 1997). With these findings in mind it is easy to recognize why aircraft overflights, along with air quality, and visitor management have been the dominant topics at the Grand Canyon recently.

Tarrant, Haas, and Manfredo (1995) examined visitor characteristics and dose exposure (number, proximity, and type) on evaluations of aircraft overflights in wilderness areas. Findings from this study indicate that respondents have strong negative attitudes toward hearing and witnessing aircraft in wilderness areas. Participants found sightseeing and single-engine aircraft the most annoying. Interestingly, visitors also reported their levels of tranquility and solitude to be negatively affected. These findings are particularly important given the explicit purpose of wilderness areas to provide "outstanding opportunities for a primitive and unconfined type of recreation" (Wilderness Act, 1964, Section 2c). Furthermore, the cognitive dimension of freedom also seems to be a relevant area of study when considering the wording of the wilderness act. The Tarrant et al. (1995) study did not, however, examine physical measurements of the intensity of aircraft noise encountered.

Recreation researchers have contributed immensely to our understanding of the wilderness or nature experience in the later part of the twentieth century. These researchers have found that a primary reason for visiting a national park, wilderness area, forest or other outdoor recreational environment is to escape the noise found in urban areas (Driver et al., 1987). Escaping from noise ranks fourth in importance of sixteen preference domains, after enjoying nature, physical fitness, and reducing tension, by users of wilderness and non-wilderness recreational areas (Driver et al., 1987).

Therefore, it can be argued that the aural component of the nature experience is a very important one. The wind rustling through the leaves, the babbling brook, the thundering waterfall, bird songs and wildlife calls are all part of experiencing and appreciating nature. It is difficult to see how these experiences would not be compromised by the auditory intrusions of aircraft, especially when considering the literature.

Natural Landscape Evaluation

When land preservation became a legislative reality, more objective approaches to landscape evaluation began to appear. Landscape evaluation became an integral research component of federal agencies in charge of managing natural parcels of land. The quantification of the land and the identified resources it contained led federal land managers to solicit the aid of social scientists in order to provide a measure of the value or worth of a given area. Researchers in disciplines including psychology, natural resources, geography, economics, landscape architecture, and forestry began to undertake the difficult task of quantifying elements of the natural landscape. Often these valuation attempts focused on a single resource such as timber, with the dependent measure being economically driven--board feet of lumber, for example. The land obviously contained a variety of other resources, and soon landscape evaluations examined aesthetic features of the landscape (Brush, 1979; Buyhoff & Wellman, 1978; Daniel & Boster, 1976; Daniel, Wheeler, Boster, & Best, 1973; Feimer, Smardon, & Craik, 1981; Zube, 1974), including what types of natural environments were preferred over others (Buyhoff & Wellman, 1978; Herzog, 1984, 1985, 1990; Hull & Stewart, 1995).

Methodological and Theoretical Issues

As a result of the interdisciplinary nature of landscape evaluation, a variety of methods have been employed when researching natural environments and their inherent resources. Advantages and disadvantages of these differing methods have been reviewed by Daniel and Vining (1983). Initially during the 1970's, federal agencies relied on expert judgment and landscape architects. With these approaches being design-oriented and focusing on formal aesthetic features of the landscape (form, color, line, texture, and variety), a realization soon emerged that these evaluations needed to include other attributes of the environment in order to provide better management alternatives (Daniel, 1990). Landscape evaluations utilizing paired comparisons (Buhyoff & Wellman, 1978), magnitude estimation (Buhyoff, Wellman, & Daniel, 1982), rating scales (Brush, 1979; Daniel & Boster, 1976), rank orders (Shafer & Brush, 1977), and Q-sorts (Pitt & Zube, 1979) began dominating the methodology used in landscape assessments.

In addition to contributing relevant data usable by federal land managers, a number of theoretical perspectives have emerged from landscape evaluation research. The literature has been grouped together in different ways by a number of researchers, often relying on the methodology employed and the goal of the evaluation as distinguishing features. Crofts (1975) discussed the relation between preference and surrogate component analysis, focusing primarily on various attributes of the terrain. Arthur (1977) also differentiated between preference (especially that of the public) and descriptive inventories, usually completed by landscape experts. Quantitative and qualitative distinctions were also made in each category of the Arthur (1977) model. Briggs and France (1980) based his distinction on methodology, differentiating between direct and indirect techniques. Daniel and Vining (1983) further differentiated the research based on methodology, creating five categories. These included the formal aesthetic, ecological, psychological, phenomenological, and psychophysical models. Wherrett (1996) split the models into descriptive, public preference, and quantitative holistic. Distinctions between models are a result, in part, of the interdisciplinary nature of the literature. While differences may reside in the categorizing of the research, it is evident that there is a growing and rather impressive literature examining evaluation and perception of the land. A careful blending of many of these models, or elements thereof, may contribute greatly to our understanding of human interactions with natural environments and provide a reliable, valid, and useful system of examining landscape quality (Kaplan, 1995; Ulrich, 1977).

Expert Versus Public Judgments

Discrepancies among researchers regarding the targeting of relevant research to distinct theoretical perspectives is not the only rift in the landscape literature. Debates have arisen regarding many other aspects of landscape evaluation, principal among them the "expert versus public" discussion. There are many who argue landscape evaluation should be completed by those trained in certain disciplines or who are working in some type of landscape management capacity. Especially with regard to aesthetic judgment, Carlson (1977) has stated the general public is simply not qualified to set adequate standards for features of the natural area under study. In Carlson's view, the opinion of more "environmentally sensitive" individuals would be the preferred method of obtaining aesthetic evaluations of natural landscapes. This view has been criticized, however, for not adequately identifying who among the public are more environmentally sensitive or, for that mater, that the general public is environmentally insensitive (Daniel, 1990). It could certainly be argued that the public has become more environmentally aware in the past 30 years.

Research specifically examining the "expert versus public" issue has found support for the inclusion of public landscape perception and evaluation. Daniel and Boster (1976) found highly consistent scenic beauty evaluations of a forest landscape from such diverse special interest groups as professional foresters and environmental activist groups, as well as college students and the general public. Similarity in scenic beauty ratings between college students and the general public have also been found in samples collected in Arizona and Virginia (Buhyoff et al., 1982). Cross-cultural evidence for consistency in scenic beauty ratings has also been found between Swedish and American samples (Ulrich, 1977). Although some studies have found differences between public samples and experts (Zube, Pitt, & Evans, 1983), the majority of findings focusing on scenic beauty and aesthetic features of the natural environment have generally found consistency between public and expert ratings (Daniel, 1990).

In a more general social context, it is abundantly evident that longstanding public support of the aesthetic qualities and scenic beauty inherent in natural landscapes led to federal legislation that protected natural land areas and the federal agencies in charge of managing them in the first place (Asleson & Moore, 1985; Daniel, 1990; Nash, 1982). Given the multiple use mandates of many of these federal agencies, public evaluation of the aesthetic and scenic features of the natural landscape seems more than adequate, and it would appear to be required. Decisions regarding management alternatives examining the aesthetics, scenic beauty or quality, and value of the land should, therefore, take data produced by the general public seriously.

Landscape Evaluations Using Psychophysics

As previously mentioned, theoretical perspectives have often been catalogued based on methodology. One distinct theoretical perspective which has been extensively used in decision-making contexts by federal land managers is the psychophysical perspective (Daniel, 1990). Studies employing the psychophysical perspective typically base their methodology on derivatives of classic Thurstonian scaling. For example, Buhyoff and Leuschner (1978) have successfully employed Thurstone's (1927) Law of Comparative Judgment into landscape evaluations. Daniel and Boster (1976) have integrated Thurstone's Law of Categorical Judgment into their scenic beauty estimation model. Likert scales, paired comparisons, rank ordering, and sorting scales are all appropriate techniques when quantitatively evaluating natural landscapes (Arthur, 1977). These procedures have been used in order to determine mathematical relationships between human perceptual judgment and the physical features of the landscape (Daniel & Vining, 1983). Physical land attributes can include topography, vegetation, and water features typically paired with psychological responses such as preference, scenic beauty or quality, and aesthetic value (Wherret, 1996). Multiple linear regression has recently been used to examine these relationships (Buhyoff, Miller, Roach, Zhou, & Fuller, 1994).

Landscape assessments utilizing psychophysical procedures have several advantages. First, they offer quantitative precision, especially when identifying subtle changes in a specific landscape. Second, clear quantitative results provide an excellent means for considering management alternatives within natural environments. These procedures also offer the advantages of objectivity and a basis in public perception (Daniel & Vining, 1983).

Psychophysical landscape evaluations have often used photographs or slide stimuli as a means of representing natural landscapes to respondents. The use of simulated landscape representations has a long and well-established history in experimental aesthetics and landscape assessment research (Shuttleworth, 1980). By using photographs or slides, researchers are able to quickly and easily obtain evaluations of several unique natural environments, or very subtle changes in a specific landscape. Control is also a significant advantage when using stimulus substitutes such as photographs or color slides. In many cases, research completed in real-world situations would simply be too costly to complete.

Not all researchers agree with the use of photographs or slides when conducting natural landscape evaluations, and have thus questioned the results from studies implementing this methodology (Henry & Matamala, 1990). Shafer and Brush (1977) have stated that the use of these stimuli in land management decision making is only appropriate if respondents rank the simulated environments in the same order as on-site visitors. These same researchers did find comparable results from both on-site evaluations and photographic simulations (Shafer & Brush, 1977). More recently, researchers have substantiated this finding by obtaining high correlations between photo-based judgments and actual on-site assessments of scenic beauty (Hetherington, Daniel, & Brown, 1993). This seems to be a rather consistent finding, as several authors have found high correlations between on-site evaluations of the actual landscape and ratings of the same landscape using photographs or color slides (Daniel & Boster, 1976; Dunn, 1976; Jackson, Hudman, & England, 1978; Malm, Kelley, Molenar, & Daniel, 1981; Shafer & Richards, 1974; Thayer, Hodgson, Gustke, Atwood, & Holmes, 1976; Zube, Pitt, & Anderson, 1975). Daniel (1990) reports the majority of these correlations to be in the range of .80 or greater. A meta-analysis completed by Stamps (1990) found a combined correlation coefficient of .86 for all studies examining the preference ratings of on-site visitors and general public ratings of photographs. Based on the collective findings of these researchers, it would appear that the use of color photographs or slides is an adequate and valid means of assessing natural landscapes in the field or the laboratory.

Discrepancies still remain, however, and the validity of stimulus substitutes is not a foregone conclusion. Pocock (1982) has argued that no matter how accurate the simulation, a photograph cannot convey the "life of the scene," and merely records everything at a single instance. Kroh and Gimblett (1992) echo these sentiments, finding that on-site land experience differs greatly from laboratory simulations of the same environment, especially because of the lack of multi-sensory stimulation in the laboratory. Thus, Kroh and Gimblett (1992) argue that preference or scenic beauty measurements obtained using stimulus surrogates are only measuring the static landscape and not the dynamic landscape that is found on-site because they are exclusively reliant on visual cues. A potential solution to this problem is the inclusion of other sensory stimuli in simulated landscape assessment in order to approximate real-world ambient conditions more accurately. The present study attempted to accomplish this with the addition of auditory stimuli commonly encountered in the visually simulated environments being rated.

Visibility Assessment Using Landscape Evaluation Techniques

One important area of landscape research has addressed the effects of air pollution on scenic quality in national park and wilderness areas. Most of the perceptual studies examining detection and changes in visibility have employed psychophysical methodologies and have used color slides and photographs as stimuli. Research in this area has been motivated by federal legislation focusing on visibility protection in nature-dominant environments, including the national park and wilderness systems. Specifically, section 169A of the Clean Air Act (1977) places the Environmental Protection Agency in charge of developing regulations to protect pristine areas from the effects of human-produced air pollution. Human-produced emissions of such compounds as sulfur dioxide, nitrogen oxides, ammonia and hydrocarbons produce a significant reduction in visibility. This legislation has placed standards on the type and amount of particulates that can be emitted from industrial plants, power stations, and automobiles, among other sources.

The Clean Air Act Amendments of 1990 also focused on the issues of protection, preservation, and enhancement of air quality in Class I Wilderness Areas. The Clean Air Act states as a national goal, "The prevention of any future and the remedying of any existing impairment of visibility in mandatory Class I Federal areas which impairment results from manmade air pollution." Many units of the national park and wilderness systems of the United States fall within the definition of a Class I Wilderness Area, and, therefore, are subject to the regulations pronounced in the Clean Air Act Amendments. However, the term "impairment" was not sufficiently defined. The Environmental Protection Agency attempted to remedy this discrepancy by defining visibility impairment as "... any humanly perceptible change in visibility." Consequently, one line of research has focused on quantification of human visual perception of haze.

Laboratory Sensitivity Studies

Although the Clean Air Act Amendments provide Class I Wilderness areas to be protected from human-produced haze, the problem arises as to the definition of exactly what human visual perception of haze entails. For this reason, a psychological measure of visual perception, combined with a physical measure of changes in air quality, is needed before regulations and control over sources of air pollution can be implemented.

When focusing on scenic areas, the quantification of perceived air quality has traditionally taken into account some physical parameter of the pollution itself (Latimer, Hogo, & Daniel, 1981). Typically, these parameters have included sky coloration, atmosphere transparency, lighting conditions, and standard visual range. Research completed utilizing these measures has predominantly been with a type of haze referred to as "plume" or "layered" haze. Plume haze is typically produced by factories or power plants that discharge their pollutants into the atmosphere through a plume-stack that extends 50 to 100 feet (15-30m) into the sky. The plume haze, because it is discharged higher into the atmosphere, produces a pollution-filled inversion layer, and is visible as a hazy band in the sky. Clearer air is usually visible above and below the band of haze. Layered haze is typically found in city environments where factories and power plants are more common (Ross, Malm, & Loomis, 1986), but can also be found in the countryside. Bands produced by layered haze often vary in dimensions and widths, and change from day to day and hour to hour. Layered haze is often a major concern during winter months as atmospheric conditions often create inversion layers where haze can be trapped at different altitudes in the atmosphere. Inversion layers can also trap the haze near the ground, resulting in a uniform blanket of haze not exceeding a certain altitude.

Malm, Ross, Loomis, Molenar, and Iyer (1986) sought to assess the sensitivity of the human visual system to plume haze. This study utilized 35mm color slides of natural scenic vistas with varying amounts of plume haze conditions taken on-site, as well as computer-generated slides of the same landscape containing similar variations in plume haze. With the development of digital imaging techniques by the Air and Water Quality Division of the National Park Service, control for variables such as sun angle, color, and overall photographic quality are now possible when using slides as stimuli in visibility research. Results indicate that small amounts of layered haze are detectable in both on-site and computer-generated scenic vistas (Malm et al., 1986).

Loomis, Kiphart, Garnand, Malm, and Molenar (1984) utilized a signal detection-type methodology to estimate the human visual threshold for layered haze. Eight different levels of layered haze were depicted using computer-generated 35mm color slides of the same scenic vista. A strict hit rate of 70 percent confirmed that under controlled laboratory conditions, the human visual system is sensitive to very low levels of layered haze.

In a more recent study utilizing similar methodology, Mace and Loomis (1995) examined the human visual detection threshold for uniform haze, using computer-generated 35mm slides taken from a monitoring station in Grand Canyon, Arizona. Uniform haze is produced from a variety of sources, with the majority of particulates emanating from motor vehicles and power plant emissions. Uniform haze, in contrast to layered haze, completely engulfs a given area, and produces no visible borders or bands.

Natural weather conditions such as wind, water vapor, and dust also produce uniform haze, thereby affecting Class I Wilderness Areas more often than plume or layered haze. Furthermore, factories and power plants which were once segregated to city environments have now spread to rural locations as a result of increased population growth and source locations of resources. Air pollution emanating from urban areas and industry, as well as the particulates discharged from power plants in rural locations, converge over Class I Wilderness Areas, especially in the Southwest, thereby forming a uniform haze which blankets entire landscapes (Ross et al., 1986). Although uniform haze is commonplace in the Southwest, it is important to point out that this phenomenon is not unique to this region. For example, in the Pacific Northwest, pollution produced by timber operations commonly blankets entire regions in and around national parks and wilderness areas with a uniform haze. Similarly, the Owens Valley in Southern California is often covered with a uniform haze caused by wind stirring dust from dry lake beds into the atmosphere.

Mace and Loomis (1995) found significant differences between pollution levels (measured by the extinction coefficient) in two conditions studied, indicating that individuals can distinguish between high and low levels of uniform haze quite accurately. A strict 70-percent hit rate was employed, with results showing detection occurring when very low levels of uniform haze were depicted. Visibility is generally characterized either by standard visual range, which is the greatest distance that a large dark object can be seen, by the contrast between the sky and the land, or by the light-extinction coefficient. Extinction refers to the attenuation of light per unit distance due to scattering and absorption by gases and particles in the atmosphere and provides a method for estimating changes in visibility. Recently, the commonly accepted metric used in air quality determinations by the national park service has become the deciview (Pitchford & Malm, 1996). A deciview is a means of quantifying haziness. A one-deciview change is a small but humanly perceptible change in haziness, or visibility. A deciview is linear with respect to perceived visual changes over its entire range, analogous to the decibel scale for sound. A one-deciview change represents a change in scenic quality that would be noticed by most people regardless of the initial visibility conditions. A deciview of zero represents clear air, while deciviews greater than zero depict proportionally increased visibility impairment.

Visibility Survey Studies Completed in the Field

The Clean Air Act Amendments focus not only on detectability but also on the impact of haze on the experience of visitors. Therefore, it is important to examine investigations completed in field settings. Investigators have focused their research endeavors using alternative methodologies such as direct visitor interviews and on-site surveys. Following the passage of the Clean Air Act (1977), initial research examined the relationship between physical air quality and visitor preferences in a field setting. Ross, Haas, Loomis, and Malm, (1984) completed a multiple-method visitor study at Grand Canyon National Park in Arizona. On-site interviews, unobtrusive observations, and surveys were employed while using the standard visual range as a physical measure of air quality. Results showed that visibility-related attributes tended to be the most important components of the recreational experience. Clean, clear air was reported by 82 percent of the sample as being a "very" to "extremely" important attribute of an enjoyable Grand Canyon experience.

Ross et al. (1986) examined the relative importance of park attributes at five national parks in an attempt to validate the results obtained at the Grand Canyon. It was found that the cleanliness of air, water, and park facilities were the most important type of park attributes regardless of which region of the United States the park was located. Therefore, visibility-related attributes appear to be an important part of an enjoyable recreation experience, at least in those parks which were examined.

Many federal agencies along with a variety of organizations and individuals are concerned with the protection of air quality in Class I Wilderness areas, as well as the impact uniform and layered haze has on visitor enjoyment and scenic beauty assessment. The present study, therefore, included slides depicting scenic environments with clear visibility along with the same environments enshrouded in either layered or uniform haze.

Attribution and the Environment

Attribution has been an important theory for decades in social psychology and more recently has been applied in certain areas of environmental psychology. Attribution of behavior and the construal of responsibility are considered by many prominent researchers to be one of the cornerstones of social psychology (Aronson, Wilson, & Akert, 1999; Weiner, 1985). Attribution theory owes its roots to Kurt Lewin (1935, 1938), whose insights influenced Rotter (1954) and Atkinson (1957, 1964), and Heider (1958). Rotter and Atkinson researched expectancy-value theory and level of aspiration as the root of attribution theory. Heider (1958) and later Kelley (1967) helped to examine the covariation principle of causal inference and developed a widely accepted theory of attribution that replaced dissonance as the dominant paradigm in social psychology during the 1970's (Weiner, 1990). At the heart of attribution theory is that individuals search for understanding and mastery of the world, and are concerned with finding out why events occur and the inference of intention (Weiner, 1990). Attribution theory fits well with the examination of control and predictability since its inherent structure includes intention and mastery. Since the time when attribution theory came to dominate social psychology, it has been applied to an extraordinary number of areas in psychology and stress research (Amirkhan, 1990). Attribution theory has been especially useful in applications of achievement, emotion, motivation, organizational contexts, clinical areas, and interpersonal relationships. The theory has been very flexible in terms of its applicability to a diverse array of issues, including many social issues, and, more recently, environmental issues as well.

Researchers have examined the applicability of attribution theory within the environmental realm in a surprisingly limited number of instances. Attribution of scarcity and abundance in a resource dilemma was examined by Rutte, Wilke, and Messick (1988), where attribution of the cause being the environment or the group was found to determine harvesting behavior. Gold and Ziegler (1995) have examined the environmental and biological dimensions of attribution, have developed and validated a scale measuring these dimensions, and have further extended this work into such issues as authoritarianism and racism. Other researchers have focused on casual attributions of technological disasters in the form of toxic spills (Brown, Williams, & Lees-Haley, 1994), finding different causal attributions being made for a company as opposed to residents of the affected community. Attribution of the greenhouse effect to individual or corporate behavior and the effects on the interpretation of climatic events is another area that has been studied (Eiser, Reicher, & Podapec, 1996). Finally, the same researchers have also examined the attribution of responsibility for a toxic chemical spill into a river (Eiser, Podapec, Reicher, & Stevenage, 1998). With the applied nature of the theory of attribution, it is surprising more researchers in environmental psychology have not used the theory in their area of research. Examples from everyday life help to illustrate how attribution theory can and is being applied in day-to-day decision making and policy direction.

Real-world examples of attribution and regulatory consequences are numerous within the environmental arena. For example, the EPA has used source attribution as a means of establishing fines for power plants violating federal emission standards (Shaver, 1998). Within landscape evaluation paradigms, identifying the source location of environments has produced significant differences in scenic quality judgments (Anderson, 1981). Participants who were told they were evaluating natural environments attributed to national park and wilderness areas produced significantly more positive ratings than those told the depicted environments were commercial timber stands or leased grazing ranges. Since visual aspects of the environment have been shown to be affected by attribution, it seems likely that other elements of the natural environment would also be significantly affected. As previously argued, landscape assessments should include sound stimuli whenever possible, with sound stimuli accurately reflecting ambient conditions in the depicted environment. As noise has become an increasingly encountered stressor in natural environments, social factors such as attribution need to be studied so that federal land managers can better enforce their multiple use mandates, and so the judicial system and affected entities have a clearer understanding of the psychological aspects of natural resource legislation.

Problem Under Study

Although Mace et al. (1999) found that simulated helicopter noise in a national park setting increased annoyance and decreased scenic beauty, attribution theory suggests that the source of the noise may be a major moderator of these effects. Specifically, in the present study it was hypothesized that helicopter noise attributed to tourist operations would have a stronger negative effect on ratings of annoyance, preference, naturalness, scenic beauty, solitude, tranquility, and freedom than noise attributed to a Park Service rescue flight or a flight for remote trail maintenance. Similarly, noise attributed to helicopter tourist operations was also expected to significantly impact positive and negative affect. Based on previous research showing that intermittent and uncontrollable noise exposure does not habituate (Fields, 1990; Griffiths, 1983; Weinstein, 1982), all noise conditions in this study were expected to be more adversely affected than the control group.

With the inclusion of many different national park landscapes in this study, a comparison between preference levels was also conducted between the different natural settings. Previous research has found that scenic beauty and landscape preference is enhanced with the presence of distant views, rugged mountain peaks, and non-turbulent water features (Herzog, 1984, 1985, 1990; Hull & Stewart, 1995). Therefore, the landscape categories of mountain peaks and water features were expected to be the most highly preferred environments. The other landscapes represented in this study were also expected to produce high positive ratings on all scales when ambient stressors were not present, as these environments were identified as national parks in the initial instruction set. In addition, the slides depicting clean, clear views of Grand Canyon and Bryce Canyon National Parks were also expected to be highly preferred. With the presence of uniform and layered haze (added with computer digitization) in these same slides, comparisons were made between the presence and absence of both types of haze. Furthermore, the design of the study allowed a combination of ambient stressors (air pollution and helicopter noise) in some conditions, thereby enabling interaction analysis. The presence of uniform and layered haze was expected to significantly decrease ratings of scenic beauty, naturalness, and overall preference. When stressors were combined, responses on the aforementioned scales were expected to become more negative still. Although escape from urban stress and restorative experiences in natural settings are thought to be therapeutic (Driver et al., 1987; Ulrich, 1993), intrusion of air and noise pollution into pristine settings may minimize or reverse important psychological benefits of such settings, including the attainment of solitude and tranquil surroundings, and the experience of freedom. These measures, therefore, were also expected to become significantly more negative when haze and noise were combined.

Chapter II

Method

Overview of the Experimental Design

This study manipulated source attribution of helicopter noise in a completely between-subjects experimental design. Participants were exposed to the same decibel level and dose exposure rate of helicopter noise in all conditions where noise was present. Source attribution was manipulated in the instruction sets given to each participant prior to the landscape evaluation portion of the study. Participants in one condition received instructions indicating that the helicopter noise could be attributed to a tourist flight. The second group received instructions attributing the noise to a Park Service rescue flight. The third group exposed to helicopter noise was told the noise could be attributed to a Park Service maintenance flight (backcountry trail improvements, for example). A control group received no information regarding helicopter noise, and noise was not present during their landscape evaluations. Helicopter noise did not exceed 60 dB(A) in any of the noise conditions. When helicopter noise was not present, background auditory stimuli consisted of nature sounds commonly found in each depicted environment. These natural sounds also did not exceed 60 dB(A). When helicopter noise was present, the mechanical sounds effectively masked the background nature sounds, consistent with on-site encounters. Nature sounds were the only sound stimuli presented in the control condition.

Participants

Two hundred university students (106 women and 94 men) completing a research requirement for general psychology or earning extra credit in another psychology course served as participants in this experiment in one of four conditions. Thus, there were a total of 50 participants in each condition. There were no restrictions for participation in this study so long as the participant had not run through the experiment previously. A few responses were missing on the landscape evaluations; however, no participant's data was entirely eliminated.

Materials

A laboratory room measuring 19 ft 9 in. (6.02 m) by 21 ft 7 in. (6.58 m) was the primary location for the landscape assessment portion of the study. All walls and the ceiling in this room were painted black in order to minimize reflection. A Bose Acoustimass surround sound speaker system wired through a Sony STRDE-925 receiver was used to present the sound stimuli to participants. Helicopter noise and nature sounds were presented in one of three randomized orders, all of which were controlled with a Gateway E-3000 computer and a Sound Blaster 16 sound-card.

Landscapes were projected using a Kodak Ektapro 9010 slide projector equipped with a Ektagraphic 178mm lens and a high-intensity bulb. Slide presentation was controlled with the Gateway computer used to project the sound. This configuration assured that the slide and sound systems were synchronized. The Kodak projector was mounted on a platform 71 in. (1.8 m) off the ground in a control room directly adjacent to the laboratory. The screen was 22 ft (6.71 m) from the projector, producing an image size of 34.5 in. (.88 m) by 51.5 in.(1.31 m). Participants were seated at tables and chairs

15 feet (4.72 m) away from the screen and separated from one another by means of wooden partitions.

Slide Stimuli

Natural environments were visually presented to participants using 35mm color slides. Landscapes depicting the desert, forest, mountain, and water subsets were taken by the experimenter and Dr. Thomas Greene of Saint Lawrence University. These slides have been used in previous experiments and have been shown to be reliable depictions of natural southwestern landscapes (Mace, 1997; Mace, Bell, & Loomis, 1999). Vistas in the uniform and layered haze categories were taken from monitoring stations at Grand Canyon and Bryce Canyon National Parks. Atmospheric visibility is assessed in the national park system by rountinely taking photographs throughout the day from stationary cameras at specific locations in numerous national parks across the country (Malm, Leiker, Molenar, & Chan, 1980). Slide photographs with the clearest possible conditions in Grand Canyon and Bryce Canyon National Parks (extinction coefficient .014) were then digitized in order to add uniform and layered haze to the base photograph.

The digitization process has several advantages, including control for contrast, light extinction, sun angle, and seasonal variations, while providing a standardized landscape for haze manipulation (Pitchford & Malm, 1996). In other words, the landscapes contain the same terrestrial features in exactly the same locations with the only variation being the amount of uniform or layered haze present. Air pollution was visible in the Grand Canyon and Bryce Canyon vistas depicting the uniform and layered haze categories at a constant extinction level found to be easily detectable in previous experiments (Mace & Loomis, 1995; Ross et al, 1986). Computer digitization of the haze slides is completed by manipulating the red, blue, and green pixels in order to produce varying haze levels. Test slides in the layered and uniform haze categories were written using a Matrix Solitaire slide writer at a resolution of 4000 dpi, with an extinction coefficient of .044. In addition, there were no other visual cues of human manipulation in any of the vistas in the uniform and layered haze categories.

In addition to the landscapes containing uniform and layered haze, natural environments with other dominant features found in the southwestern quadrant of the United States were also used as slide stimuli. These landscapes consisted of national park vistas and included four environmental subsets: (1) desert vistas (taken from Canyonlands and Arches National Parks in Utah); (2) forest scenes (taken from Rocky Mountain National Park in Colorado); (3) mountain peaks (taken from Rocky Mountain National Park); and (4) non-turbulent mountain water features (also taken from Rocky Mountain National Park). All depicted landscapes were photographed in June and contained no signs of human manipulation. Each depicted landscape was rated on seven dependent scales: scenic beauty, naturalness, freedom, solitude, tranquility, annoyance, and overall preference.

Questionnaires

PANAS. Prior to the landscape evaluations, participants completed the Positive and Negative Affect Scale (PANAS) developed by Watson, Clark, and Tellegen, (1988). The PANAS is a short 20-item, five-point Likert-type scale that has been found to yield valid and reliable measures of reported positive and negative affect. Reliabilities range from .86 to .90 for positive affect and .84 to .87 for negative affect. Convergent validaties for both positive and negative affect have been found to be very good at .89 and .95 respectively. Discriminant validity, however, has been found to be somewhat low ranging from -.02 to -.08 (Watson et al., 1988). Following the landscape ratings, participants also completed the PANAS once again. Therefore, measures of positive and negative affect were completed using a pre-post design.

Landscape assessment scales. Each simulated environment was rated on the following attributes, which have been found to be important components of a beneficial park or wilderness experience: scenic beauty, solitude, tranquility, freedom, naturalness, annoyance, and overall preference. These scales have been used in previous research (Mace, 1997) and were found to load on a single factor with an eigen value of 4.61, and accounting for 66% of the variance (Mace, 1997). Previous landscape evaluations have focused almost exclusively on visual attributes of the environment, and have, consequently, relied on a single dependent variable such as scenic beauty (Daniel & Boster, 1976), scenic quality (Daniel, 1990; Daniel, Wheeler, Boster, & Best, 1973; Zube, 1974), preference (Buhyoff & Wellman, 1978), or visual attractiveness (Brush, 1979). Within the landscape assessment literature, it is generally accepted that these landscape descriptors are measuring the same factor, namely the overall scenic beauty and preference for landscapes (Daniel, 1990; Daniel & Vining, 1983).

Demographic information and noise sensitivity. The final measures completed by participants were questions asking for demographic information and the Weinstein Noise Sensitivity survey (Weinstein, 1982). Data on age, gender, and size of hometown, along with the frequency and recency of visitation to a national park was collected using a personal computer following completion of all other aspects of the study. Attitude questions regarding the use of helicopters in national parks were also included in this computer task. A complete list of the demographic and attitude questions can be found in the appendices.

Procedure

Participants entered the laboratory and were seated at one of six randomly chosen seating locations. Individuals were separated from one another by means of a wooden partition and given an informed consent form detailing the study and the legal requirements dictated by the human research committee. Following completion of the informed consent (Appendix A), participants completed the PANAS (Appendix B) for the first time. Once this survey was completed and collected, the landscape assessment portion of the experiment began.

Landscape assessment instructions were distributed to each participant in one of four randomly assigned conditions (Appendices C - F). Experimental design was completely between, with subjects participating in only one of the four conditions. Instructional sets were exactly the same for each of the four conditions except for the attribution of the helicopter noise. Participants were told the helicopter noise they were going to experience could be attributed to either: 1) a tourist overflight, 2) a National Park Service rescue flight to aid a backcountry visitor, or 3) a National Park Service trail maintenance flight. Those in the control condition were not exposed to helicopter noise, and thus received no mention of helicopter noise in their instruction set. Participants in the control condition rated each depicted landscape with only natural auditory stimuli being present. Once instructions were clearly understood by each participant and all questions were addressed, the landscape ratings were completed.

Participants were shown 30 slides of national park landscapes commonly found throughout the southwestern region of the United States in one of three randomized orders. The first six slides shown were practice slides and were not included in any of the analyses. Sets of slides depicting different environments were included in order to ascertain the effects of helicopter noise in a variety of nature dominant settings. Each of the six environmental sets consisted of four slides. The environmental sets used in this study were mountain peaks, forests, non-turbulent water features, desert arches and canyons, and vistas affected by either uniform or layered haze taken from Grand Canyon and Bryce Canyon National Parks.

Coinciding with each depicted landscape were auditory stimuli commonly found in each environment. These natural environmental sounds were used as background, ambient conditions and were the exclusive sounds in the control condition. Furthermore, the background auditory stimuli masked any noise emanating from the slide projector fan while also creating a more representative simulation of each landscape. In the three noise conditions, sounds from helicopters were interspersed with the ambient natural sounds. Helicopter noise was present on 12 of 24 trials, an exposure rate that can be commonly found in many national parks located in the southwestern portion of the U.S. The exposure rate used in this study was actually well below the busiest conditions in the most affected areas. In no instance did sound levels exceed 60 dB(A).

Participants viewed each depicted landscape and listened to the auditory stimuli for 32 seconds. Therefore, participants rated the depicted landscapes for a total of 16 minutes. Following completion of the environmental assessment portion of the experiment, participants were given the positive and negative affect measure once again.

When this scale was completed, participants provided demographic and attitude information (Appendix H) using a personal computer. Participants then completed a 21-item Likert-type noise sensitivity survey (Appendix I). Once participants completed the noise sensitivity scale, they were fully debriefed (Appendix J), and were free to leave.

Chapter III

Results

Overview of Statistical Analyses

Landscape evaluation data were analyzed with several statistical procedures. Each participant rated a total of 30 landscapes, with the first six natural environments considered practice trials. Data from the practice trials were not included in any further analysis. Therefore, the following statistical results examining landscape ratings are based on 24 different natural environment ratings. Analysis focused initially on aggregate data from all environments in each of the four noise conditions, but was additionally broken down by environment for a more in-depth analysis of landscape preference.

Raw data from the seven dependent landscape rating variables for each rated environment were fed into a computer program in order to transform the randomized orders into a consolidated data file. Intercorrelations between the dependent landscape rating variables were calculated across all slide stimuli in all four conditions. High, significant correlations were obtained for all seven dependent measures, allowing for multivariate statistical analysis. Means and standard deviations were also calculated for each dependent variable in all four conditions. Univariate analyses were conducted for each of the seven dependent variables in each of the four conditions. Planned contrasts between conditions were conducted in order to ascertain where differences existed.

Positive and negative affect were analyzed with a pre-post procedure in order to ascertain if exposure to helicopter noise had an effect on self-reported emotional state.

Finally, multiple regression was also conducted with the landscape ratings using overall landscape preference as the dependent variable and the other six landscape measures as predictors.

Landscape Scaling Procedures

Individual ratings for each depicted vista were input in a computerized statistical program (SPSS) for all statistical analyses. Each landscape was rated on a 10-point, Likert-type scale ranging from very low (1) to very high (10) for each of the seven dependent variables. Ratings were completed for each depicted landscape on dimensions of scenic beauty, naturalness, freedom, solitude, tranquility, annoyance, and overall preference. These variables were found to be highly correlated with one another (see Table 1). All correlations were found to be significant at a probability level of .001. All but one of the correlations ranged between .31 to .86. As seen in Table 1, the highest correlation was found between solitude and tranquility, with other high correlations between solitude, tranquility, freedom, and preference. Annoyance was found to be highly negatively correlated with all other dependent variables except scenic beauty, which was the smallest correlation, although it remained significant at an alpha level of .001. The highest negative correlations were found between annoyance and tranquility (-.79), and annoyance and solitude (-.74). Overall preference and annoyance were also highly negatively correlated (-.67). Negative correlations were obtained with annoyance and the other predictors, as a higher score on annoyance becomes more negative, while a higher score on one of the other six dependent scales represents a positive increase.

Table 1

Correlations of Dependent Measures for all Rated Environments

	Annoyance	Freedom	Naturalness	Preference	Scenic Beauty	Solitude	Tranquility
Annoyance	1.0000						
Freedom	-.6081*	1.0000					
Naturalness	-.4574*	.6915*	1.0000				
Preference	-.6668*	.7482*	.6134*	1.0000			
Scenic Beauty	-.2212*	.5103*	.5880*	.5522*	1.0000		
Solitude	-.7361*	.7142*	.5505*	.7314*	.3188*	1.0000	
Tranquility	-.7889*	.7222*	.5755*	.8033*	.3644*	.8549*	1.0000

* For all correlations, $p<.001$

Means and standard deviations for all landscape assessments can be found in Table 2. Relatively high ratings were obtained for all depicted scenic vistas for scenic beauty, M = 8.17, and naturalness, M = 7.97. Standard deviations are quite large and range from 1.8 to 3.4, primarily as a result of combining all conditions (including those exposed to helicopter noise) into the calculation of these means and standard deviations. As would be expected when all conditions are combined, annoyance had a large deviation and an inflated mean as a result. Similarly, mean ratings for solitude and tranquility (among others) were deflated because of the noise exposure, again exhibiting rather large standard deviations.

More meaningful results can be obtained by examining the means and standard deviations for each condition. As seen in Table 3, the control condition produced relatively high means for all scales except annoyance. In this condition, annoyance was rather low, M = 2.2, SD = 1.8. Naturalness and scenic beauty produced the largest means (8.65 and 8.31, respectively) in the control condition. This trend remained true in the three noise conditions as well, although the means were predominantly lower and the standard deviations were much higher in the noise conditions. However, in the tourist noise condition, scenic beauty was nearly identical to the control condition.

In all three noise conditions, the means produced for annoyance were much higher than the control condition where only nature sounds were audible. Solitude, tranquility, and overall preference greatly declined with the presence of helicopter noise independent of the attributed source. Standard deviations were, however, once again rather large for all of the dependent measures when comparing them to those produced by the control condition. The large deviations may be a result of noise not being

Table 2

Means and Standard Deviations for the Seven Dependent Landscape Ratings.

Variable	N	M	SD
Annoyance	4764	4.1507	3.3758
Freedom	4763	7.2528	2.3806
Naturalness	4765	7.9696	2.1608
Preference	4747	6.4881	2.6762
Scenic Beauty	4766	8.1727	1.8802
Tranquility	4752	6.3843	2.9316
Solitude	4761	6.5316	2.8826

Table 3

Means and Standard Deviations for the Seven Dependent Landscape Rating Scales by Condition.

Condition	Annoyance	Freedom	Naturalness	Preference	Solitude	Tranquility	Scenic Beauty
Control							
M	2.1877	8.1759	8.6465	7.5939	7.9798	7.9519	8.3064
SD	1.8318	1.9376	1.8097	2.2844	2.1245	1.9587	1.8609
Tour							
M	4.9019	6.9044	7.6899	6.1886	6.0687	5.8416	8.3194
SD	3.6132	2.5941	2.3855	2.6752	2.9481	3.0448	1.8859
NPS Rescue							
M	4.6748	6.9352	7.7807	6.0592	5.8965	5.7855	8.1411
SD	3.6177	2.4911	2.2993	2.8597	3.1148	3.2050	1.9181
NPS Trail Maint.							
M	4.8315	6.9983	7.7638	6.1160	6.1846	5.9630	7.9246
SD	3.3077	2.2028	1.9541	2.5455	2.7409	2.7799	1.8300

continuously present throughout all landscape ratings. Recall that sounds of nature were also present in the three noise conditions, making up a total of half of the landscape ratings in these conditions. In other words, perhaps the participants in these conditions varied their ratings when noise was present compared to when nature sounds were present. This issue is addressed in greater depth with a series of post-hoc analyses later in this chapter.

As previously mentioned, the high correlations depicted in Table 1 argue for a multivariate analysis of variance in order to determine if the presence of helicopter noise had a significant effect on the seven dependent measures used in the assessment of the natural landscapes. A completely between-subjects MANOVA was performed on the seven dependent variables: annoyance, freedom, naturalness, preference, solitude, tranquility, and scenic beauty. Significant differences were found to exist between the four conditions, $F(3, 2366) = 35.87$, $p<.0001$. Effect size estimates utilizing the eta square statistic indicated that this effect accounted for 5 percent of the variance.

Demographic variables such as gender, age, size of hometown, and whether or not an individual had recently visited a national park and flown on a helicopter tour were included in this analysis as covariates. In no instance did any of these demographic measures produce significant differences on any of the seven dependent measures. Noise sensitivity was assessed with the Weinstein Noise Sensitivity Scale and included as another covariate. A median split of 81.2 was obtained (with an overall range of 21 to 126). Those individuals below this value were then categorized as low with regard to noise sensitivity, and those scoring 82 or above were classified as highly sensitive to noise. Noise sensitivity (low versus high) did not have an effect on any of the dependent measures.

Univariate analyses of variance were completed in order to ascertain which dependent landscape measures were contributing to the overall significant effect. Results from the univariate analyses can be found in Table 4. As shown in this Table, all seven dependent measures were found to be significantly affected by the noise. As hypothesized, ratings of annoyance were significantly affected by the presence of helicopter noise, $F(3, 4741) = 200.44$, $p<.001$, eta square = .11. Tranquility, $F(3, 4741) = 167.38$, $p<.001$, eta square = .10, and solitude, $F(3,4741) = 147.95$, $p<.001$, eta square = .09, were also significantly affected by the presence of helicopter noise. Overall preference was found to be significantly reduced when helicopter noise was present, $F(3,4741) = 95.59$, $p<.001$, eta square = .06. Likewise, the predominantly cognitive dimension of freedom was significantly restricted in the helicopter noise conditions, $F(3,4741) = 83.58$, $p<.001$, eta square = .05. Although naturalness was affected by the presence of helicopter noise, $F(3, 4741) = 53.60$, $p<.001$, eta square = .03, the effect was not as strong as was hypothesized or would be expected. Scenic beauty, which has been primarily considered a visual process of landscape assessment was also found to be affected by the helicopter noise, although the effect was very weak, $F(3, 4741) = 11.71$, $p<.001$, eta square = .01.

Contrasts Between Conditions

Differences were expected to exist between the control condition and the three noise conditions, as well as between the three noise conditions themselves. Table 5 shows the results from multivariate contrasts between all four conditions. As

Table 4

Univariate Analyses of Variance for the Overall Main Effect of Noise Attribution

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Annoyance	6094.799	48027.171	2031.600	10.130	200.549	<.001	.112
Freedom	1352.242	25569.691	450.747	5.393	83.575	<.001	.050
Naturalness	723.472	21331.183	241.157	4.499	53.599	<.001	.033
Scenic Beauty	123.501	16668.503	41.167	3.516	11.709	<.001	.007
Preference	1937.971	32039.508	645.990	6.758	95.589	<.001	.057
Solitude	3375.120	36051.903	1125.040	7.604	147.948	<.001	.086
Tranquility	3907.256	36889.727	1302.419	7.781	167.384	<.001	.096

Table 5

Multivariate Analyses of Variance Contrasts Between Conditions

Comparison	Wilk's Value	Hypoth. dF	Error dF	F	Sig. of F	eta-square
Control vs Tourist	.788	7	2367	91.173	<.001	.212
Control vs NPS Rescue	.809	7	2355	79.599	<.001	.191
Control vs Trail Maint.	.792	7	2363	88.919	<.001	.208
Tourist vs NPS Rescue	.986	7	2366	4.947	<.001	.014
Tourist vs Trail Maint.	.979	7	2374	7.416	<.001	.021
NPS Rescue vs Trail Maint.	.981	7	2362	6.691	<.001	.019

hypothesized, differences were found to reside between the control condition and the three noise conditions. The greatest difference was found to exist between the control group and the tourist helicopter noise condition, $F(7, 2367) = 91.17$, $p<.001$, eta square = .21. Strong, significant differences were also found between the control condition and the national park service (NPS) trail maintenance condition, $F(7, 2363) = 88.92$, $p<.001$, eta square = .21, as well as the control condition and the NPS rescue noise condition, $F(7, 2355) = 79.60$, $p<.001$, eta square =.19. Small but significant differences were found to exist between the three noise conditions. These differences will be described in more detail in the following section, as each multivariate contrast is followed with individual univariate analyses.

With a strong, significant difference realized between the control condition and the tourist flight noise condition, univariate analyses of variance were performed in order to examine the specific contributions to the overall multivariate effect. Univariate analyses for the seven dependent measures between the tourist noise condition and the control condition are presented in Table 6. Annoyance was found to be significantly different between these two conditions, $F(1, 2373) = 528.95$, $p<.001$, eta square = .18, showing a strong effect. Tranquility, $F(1, 2373) = 403.54$, $p<.001$, eta square =.15, and solitude, $F(1, 2373) = 331.11$, $p<.001$, eta square = .12, were also found to be significantly different between the control condition and the tourist flight helicopter noise condition. Overall preference of the landscapes was also found to be significantly different between the two conditions, with the presence of tourist flight helicopter noise significantly reducing the overall preference of the natural environment, $F(1, 2373) = 189.37$, $p<.001$, eta square = .07. Freedom and naturalness also significantly differed

Table 6

Univariate Analyses of Variance for the Control Condition versus the Tourist Noise Condition

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Annoyance	4354.638	19536.159	4354.638	8.233	528.945	<.001	.182
Freedom	966.346	12469.723	966.346	5.255	183.897	<.001	.072
Naturalness	545.134	10658.838	545.134	4.492	121.364	<.001	.049
Scenic Beauty	0.013	8328.247	0.013	3.510	0.004	.952	
Preference	1172.567	14693.641	1172.567	6.192	189.368	<.001	.074
Solitude	2185.506	15663.173	2185.506	6.601	331.108	<.001	.122
Tranquility	2650.245	15584.591	2650.245	6.567	403.542	<.001	.145

between the two conditions, bringing the total to six of the seven dependent measures reaching significance. Interestingly, scenic beauty was the one dependent variable that was not found to be significantly different between the control condition and the tourist flight noise condition, $F(1, 2373) = 0.004$, $p=.95$. This finding has potentially interesting implications which will be further explored in the following chapter.

Multivariate comparison also yielded a strong, significant difference between the control condition and the NPS rescue helicopter noise condition. Table 7 depicts univariate analyses for the contrast between the control condition and the NPS rescue helicopter noise condition. Annoyance was found to produce the largest difference between these two conditions, producing a strong, significant effect, $F(1, 2372) = 442.77$, $p<.001$, eta square = .16. Tranquility and solitude were also significantly different between these two conditions, producing results of $F(1, 2372) = 394.77$, $p<.001$, eta square = .14, and, $F(1, 2372) = 362.06$, $p<.001$, eta square = .13, respectively. In fact, all seven dependent variables were found to significantly differ between the control condition and the NPS rescue helicopter noise condition. Scenic beauty, however, was found to be significantly reduced in the rescue noise condition, albeit at a different probability level than the other six landscape scales, $F(1, 2372) = 4.56$, $p<.05$, eta square = .002, with the effect being very weak based on the effect size statistic. As with the differences found between the control condition and the tourist noise condition, the comparisons between the control condition and the NPS rescue noise condition were also found to significantly differ on landscape ratings of naturalness, freedom, and overall preference for the depicted natural environments.

Table 7

Univariate Analyses of Variance for the Control Condition versus the NPS Rescue Noise Condition

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Annoyance	3649.030	19458.007	3649.030	8.241	442.767	<.001	.158
Freedom	906.328	11771.585	906.328	4.986	181.780	<.001	.071
Naturalness	428.095	9996.818	428.095	4.234	101.105	<.001	.041
Preference	1392.817	15820.045	1392.817	6.701	207.865	<.001	.081
Scenic Beauty	16.385	8441.992	16.385	3.576	4.582	<.05	.002
Solitude	2569.432	16755.416	2569.432	7.097	362.058	<.001	.133
Tranquility	2786.725	16666.607	2786.725	7.059	394.769	<.001	.143

The final noise condition, with the helicopter noise attributed to an NPS backcountry trail maintenance flight, also significantly differed from the control condition based on multivariate contrast results. Table 8 depicts the univariate comparisons between the NPS backcountry trail maintenance helicopter noise condition and the control condition. Once again, annoyance was found to significantly differ between these two conditions, $F(1, 2372) = 579.12$, $p<.001$, eta square = .20. As found in the contrasts between the other two noise conditions and the control condition, tranquility and solitude were found to be greatly affected by the presence of helicopter noise in the NPS backcountry trail maintenance condition. Specifically, the univariate analysis for tranquility was found to differ tremendously between the control and backcountry trail maintenance condtions, $F(1, 2372) = 407.65$, $p<.001$, eta square = .15. Solitude strongly differed between these two conditions, $F(1, 2372) = 321.83$, $p<.001$, eta square = .12, showing that helicopter noise attributed to an NPS trail building flight does interfere with the attainment of solitude or serenity. Overall preference for the depicted environments significantly differed between the two conditions, $F(1, 2372) = 222.41$, $p<.001$, eta square = .09. Perception of freedom within the landscapes was also negatively affected with the presence of helicopter noise attributed to an NPS maintenance flight, $F(1, 2372) = 191.55$, $p<.001$, eta square = .08. The environments were perceived as significantly less natural when helicopter noise was present, $F(1, 2372) = 130.59$, $p<.001$, eta square = .05, and ratings of scenic beauty also significantly declined when noise was present, $F(1,2372) = 26.5$, $p<.001$, eta square = .01. In total, all seven dependent measures were found to significantly differ between the control condition and the NPS trail maintenance noise condition.

Table 8

Univariate Analyses of Variance for the Control Condition versus the NPS Trail Maintenance Noise Condition

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Annoyance	4151.445	16982.272	4151.445	7.169	579.120	<.001	.196
Freedom	826.799	10225.616	826.799	4.316	191.547	<.001	.075
Naturalness	464.492	8426.707	464.492	3.557	130.583	<.001	.052
Preference	1300.470	13851.974	1300.470	5.847	222.410	<.001	.086
Scenic Beauty	90.348	8076.111	90.348	3.409	26.502	<.001	.011
Solitude	1934.357	14238.932	1934.357	6.011	321.828	<.001	.120
Tranquility	2358.394	13705.595	2358.394	5.785	407.646	<.001	.147

Univariate analyses were also conducted between the three noise conditions in order to determine the specific differences accounting for the multivariate effects. Univariate analyses of variance for the helicopter tour flight noise condition and the NPS helicopter rescue noise condition can be found in Table 9. Scenic beauty was the only dependent scale that was found to differ between the two conditions. Specifically, scenic beauty significantly declined when the helicopter noise was attributed to an NPS helicopter rescue flight compared to a helicopter tour flight, $F(1, 2372) = 4.8$, $p<.05$, although the effect size was found to be minimal, eta square = .002. With no other significant differences being realized between these two conditions on the remaining dependent measures, it appears that helicopter noise, when attributed to either a tourist flight or an NPS rescue flight, has similar effects on levels of annoyance, tranquility, solitude, naturalness, perceptions of freedom, and overall preference for the depicted landscapes.

Univariate analyses of variance for the multivariate comparison between the helicopter tourist noise condition and the NPS trail maintenance condition can be found in Table 10. As found in the aforementioned contrast, significant differences were found between these two conditions on ratings of scenic beauty for the portrayed landscapes. Scenic beauty was found to be significantly lower in the NPS trail maintenance condition when compared to the tourist flight condition, $F(1, 2372) = 26.89$, $p<.001$, although the effect size is rather small, eta square = .01. The other six dependent measures did not significantly differ between the tourist flight and the NPS trail flight noise conditions.

Table 9

Univariate Analyses of Variance for the Tourist Noise Condition versus the NPS Rescue Noise Condition

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Annoyance	29.472	31044.899	29.472	13.091	2.252	.134	
Freedom	0.818	15344.075	0.818	6.469	0.127	.722	
Naturalness	6.785	12904.475	6.785	5.440	1.247	.264	
Scenic Beauty	17.391	8592.391	17.391	3.622	4.801	.029	.002
Preference	10.057	18187.534	10.057	7.668	1.312	.252	
Solitude	16.543	21812.970	16.543	9.196	1.799	.180	
Tranquility	2.079	23184.131	2.079	9.774	0.213	.645	

Table 10

Univariate Analyses of Variance for the Tourist Noise Condition versus the NPS Trail Maintenance Noise Condition

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Annoyance	2.269	28569.164	2.269	12.004	.189	.664	
Freedom	5.342	13798.106	5.342	5.798	.921	.337	
Naturalness	3.171	11334.364	3.171	4.762	.666	.415	
Preference	3.431	16219.463	3.431	6.815	.503	.478	
Scenic Beauty	92.939	8226.510	92.939	3.457	26.888	<.001	.011
Solitude	7.482	19296.487	7.482	8.108	.923	.337	
Tranquility	8.299	20223.120	8.299	8.497	.977	.323	

Table 11 illustrates univariate analyses of variance for the contrast between the NPS rescue flight noise condition and the NPS trail maintenance noise condition. Once again, scenic beauty was found to be significantly different between noise conditions. Scenic beauty was found to be slightly, but significantly lower in the NPS trail maintenance flight noise condition than when the helicopter noise was attributed to the park service flying rescue operations, $\underline{F}(1, 2372) = 8.43$, $\underline{p}<.01$, although the effect size is basically non-existent, eta square = .004. Interestingly, solitude also significantly differed between the two NPS noise conditions. The experience of solitude was found to be slightly lower in the NPS rescue condition than when the helicopter noise was attributed to the park service flying materials into the backcountry for the completion of trail maintenance, $\underline{F}(1,2372) = 5.36$, $\underline{p}<.05$, eta square = .002. Annoyance level, perception of freedom, the naturalness of the environment, overall preference for the landscape and tranquility were not significantly different between the two NPS helicopter noise conditions. In fact, when examining the means for the three noise conditions (see Table 3), it becomes apparent that the dependent measures are strikingly similar for most of the landscape attributes. This suggests that while there are subtle differences between the noise conditions on the scenic quality of the environments, the mere presence of helicopter noise, at least in those conditions and environments studied, appears to cause important psychological reactions, regardless of the source of the helicopter noise.

Individual Noise and Nature Trials Within the Three Noise Conditions

Recall that noise was present on half of the landscape rating trials within each of the three noise conditions. Based on the large standard deviations for many of the dependent variables in the noise conditions (refer to Table 3), post-hoc analyses were

Table 11

Univariate Analyses of Variance for the NPS Rescue Noise Condition versus the NPS Trail Maintenance Noise Condition

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Annoyance	15.380	28491.012	15.380	12.032	1.278	.258	
Freedom	1.965	13099.968	1.965	5.532	.355	.551	
Naturalness	.683	10672.344	.683	4.507	.152	.697	
Scenic Beauty	29.695	8340.256	29.695	3.522	8.431	.004	.004
Preference	1.745	17345.867	1.745	7.325	.238	.626	
Solitude	46.136	20388.729	46.136	8.610	5.358	.021	.002
Tranquility	18.613	21305.136	18.613	8.997	2.069	.150	

conducted in order to examine the differences between trials where noise was present and not present within each of the three helicopter noise conditions. Means and standard deviations for the three noise conditions where noise was either present or not present can be found in Table 12. There are many interesting comparisons when examining the means for the three conditions. Annoyance, for example, exhibits striking differences in all three noise conditions when helicopter noise was present compared to when nature sounds were present. As would be expected, ratings of solitude and tranquility are greatly affected by the presence of helicopter noise within each of the three noise conditions. Overall preference also declines dramatically when the landscape is affected by helicopter noise from a tourist flight.

Large differences between most of the dependent variables in the three noise conditions when helicopter noise was present versus when nature sounds were present argued for a multivariate analysis of variance in each condition in order to test for significance and strength of association. Based on MANOVA, landscape ratings in the scenic helicopter tour condition were negatively affected by the presence of helicopter noise, $F(7, 1185) = 275.56$, $p<.001$. When examining the effect size measure, it is strikingly evident how strongly the landscape ratings were affected by the presence of helicopter noise attributed to a tourist flight, eta square = .62. Univariate analyses of variance were conducted in order to examine which landscape variables were accounting for the large difference, and can be found in Table 13. All seven dependent variables were affected by the presence of helicopter noise compared to nature sounds within the tourist flight condition. Annoyance was especially affected on helicopter noise trials, $F(1, 1191) = 1780.08$, $p<.001$, eta square = .60. Solitude and tranquility were also

Table 12

Means and Standard Deviations for the Seven Dependent Scales for each Noise

Condition when Helicopter Noise was either Present or when Nature Sounds were Present.

Condition	Annoyance	Freedom	Naturalness	Preference	Solitude	Tranquility	Scenic Beauty
Tour Flight							
Noise							
M	8.8960	5.5662	6.8241	4.7755	4.0754	3.7839	8.1792
SD	1.9556	2.4538	2.6224	2.1936	2.2027	2.1780	1.9464
Nature							
M	3.3049	8.2450	8.5570	7.6040	8.0654	7.9027	8.4597
SD	2.5785	1.9628	1.7340	2.3467	2.1383	2.3061	1.8141
NPS Rescue							
Noise							
M	9.1191	5.6728	7.0236	4.3682	3.7686	3.4274	7.8706
SD	2.8225	2.4703	2.4535	2.4741	2.4876	2.4199	2.0280
Nature							
M	3.5219	8.1913	8.5352	7.7559	8.0101	8.1436	8.4111
SD	1.5965	1.7748	1.8499	2.1207	2.0563	1.8881	1.7625
NPS Trail Maint.							
Noise							
M	8.8221	6.0284	7.1622	4.8074	4.4472	4.0385	7.7375
SD	1.7146	2.1324	2.0834	2.2416	2.2352	2.1340	1.8959
Nature							
M	3.5193	7.9731	8.3674	7.4334	7.9277	7.9005	8.1124
SD	2.2078	1.8079	1.6038	2.1188	1.9932	1.8550	1.7429

Table 13

Univariate Analyses of Variance for the Tourist Flight Noise

Condition Comparison Between Trials with Noise and Nature Sounds

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Annoyance	9323.459	6238.066	9323.459	5.238	1780.077	<.001	.599
Freedom	2140.235	5880.871	2140.235	4.938	433.443	<.001	.267
Naturalness	895.654	5887.593	895.654	4.943	181.182	<.001	.132
Scenic Beauty	23.467	4215.856	23.467	3.540	6.629	<.01	.006
Preference	2386.092	6144.473	2386.092	5.159	462.503	<.001	.280
Solitude	4748.308	5612.056	4748.308	4.712	1007.694	<.001	.458
Tranquility	5059.577	5991.481	5059.577	5.031	1005.754	<.001	.458

negatively affected by the presence of helicopter noise, as were overall preference for the environment, $F(1,1191) = 462.50$, $p<.001$, eta square = .28, and the amount of perceived freedom present within the environment, $F(1, 1191) = 433.44$, $p<.001$, eta square = .27. Depicted environments were also perceived as less natural when helicopter noise attributed to a tourist flight was present, $F(1, 1191) = 181.18$, $p<.001$, eta square = .13.

Helicopter noise attributed to the Park Service flying helicopters for backcountry rescue purposes was the next condition to be examined for differences between noise and nature trials. When helicopter noise was present and attributed to this purpose, landscape ratings were found to be significantly more negative than when nature sounds were audible, $F(7, 1173) = 297.62$, $p<.001$, eta square = .64. Univariate analyses were conducted on the seven dependent landscape measures with results being visible in Table 14. Helicopter noise, when attributed to an NPS rescue flight, significantly increased annoyance and significantly decreased all other dependent measures. Annoyance, as in the tourist flight condition, was strongly affected on those trials where helicopter noise attributed to an NPS rescue flight was present, $F(1, 1179) = 1760.50$, $p<.001$, eta square = .60. Other variables strongly affected include tranquility, $F(1, 1179) = 1390.78$, $p<.001$, eta square = . 54, solitude, $F(1, 1179) = 1046.46$, $p<.001$, eta square = .47, overall preference for the depicted environments, $F(1, 1179) = 639.89$, $p<.001$, eta square = .35, and feelings of freedom, $F(1, 1179) = 412.32$, $p<.001$, eta square = .26. Perceived naturalness of the environment was also affected by helicopter noise on those trials where it was present in the NPS rescue condition, as was scenic beauty, although the effect size is rather small. Overall, however, it appears that on those trials where helicopter noise was present and attributable to the NPS engaging in backcountry rescue flights,

Table 14

Univariate Analyses of Variance for the NPS Rescue Flight Noise

Condition Comparison Between Trials with Noise and Nature Sounds

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Annoyance	9273.169	6210.204	9273.169	5.267	1760.500	<.001	.599
Freedom	1897.405	5425.563	1897.405	4.602	412.315	<.001	.259
Naturalness	707.049	5414.179	707.049	4.592	153.968	<.001	.116
Scenic Beauty	91.735	4261.334	91.735	3.614	25.381	<.001	.021
Preference	3397.329	6259.639	3397.329	5.309	639.885	<.001	.352
Solitude	5385.261	6067.345	5385.261	5.146	1046.458	<.001	.470
Tranquility	6566.485	5566.589	6566.485	4.721	1390.777	<.001	.541

ratings of environmental quality significantly declined.

On those trials where helicopter noise was attributed to an NPS backcountry trail maintenance flight, landscape ratings were found to be significantly more negative when helicopter noise was present, based on a multivariate analysis of variance, $F(7, 1181) = 332.68$, $p<.001$, eta square = .66. Univariate analyses of the seven landscape rating measures can be found in Table 15. Annoyance was found to be impacted in a very strong negative manner on those trials when helicopter noise was present, $F(1, 1187) = 2135.30$, $p<.001$, eta square = .64. Other strongly affected variables included tranquility, $F(1, 1187) = 1106.58$, $p<.001$, eta square = .48, solitude, $F(1, 1187) = 802.12$, $p<.001$, eta square = .48, and overall preference for the scenic landscapes, $F(1, 1187) = 429.53$, $p<.001$, eta square = .27. It is also important to note that the cognitive dimension of freedom, as well as perceptions of the scenic beauty of the environment were also negatively impacted by the presence of helicopter noise attributed to a Park Service backcountry maintenance flight. In all three conditions where helicopter noise was present, landscapes became significantly more negative regardless of the attributed source of the noise. Based on these results, and others previously discussed, it appears that the mere presence of helicopter noise in natural landscapes triggers important psychological reactions and may interfere with the attainment of some rather important outcome experiences.

There are, however, subtle differences between the three conditions exposed to helicopter noise, based on MANOVA. The three noise conditions were found to significantly differ from one another on those trials when helicopter noise was present, $F(14, 3552) = 7.12$, $p<.001$, eta square = .03. Univariate results found the three noise

Table 15

Univariate Analyses of Variance for the NPS Trail Flight Noise

Condition Comparison Between Trials with Noise and Nature Sounds

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Annoyance	8360.233	4647.405	8360.233	3.915	2135.298	<.001	.643
Freedom	1141.496	4635.503	1141.496	3.905	292.299	<.001	.198
Naturalness	434.569	4116.548	434.569	3.468	125.307	<.001	.095
Scenic Beauty	42.814	3944.373	42.814	3.323	12.884	<.001	.011
Preference	2043.030	5645.868	2043.030	4.756	429.531	<.001	.266
Solitude	3603.515	5332.608	3603.515	4.493	802.116	<.001	.403
Tranquility	4425.234	4746.828	4425.234	3.999	1106.582	<.001	.482

conditions to differ significantly on ratings of solitude, $F(2, 1782) = 12.85$, $p<.001$, eta square = .01, tranquility, $F(2, 1782) = 11.11$, $p<.001$, eta square = .01, scenic beauty, $F(2, 1782) = 8.06$, $p<.001$, eta square =.01, freedom, $F(2, 1782) = 6.12$, $p<.01$, eta square = .01, and overall preference for the environment, $F(2, 1782) = 6.82$, $p<.01$, eta square = .01. Although these differences are significant, they are small based on the effect size measures. Caution must therefore be taken when interpreting these results.

Follow-up analyses were conducted between the three individual noise conditions in order to directly examine the differences between conditions on the landscape measures on those trials when helicopter noise was present. Significant differences were found to exist between the tourist flight condition and the Park Service rescue condition. Specifically, ratings of overall preference, $F(1, 1186) = 9.22$, $p<.01$, eta square = .01, scenic beauty, $F(1, 1186) = 7.19$, $p<.01$, eta square = .01, tranquility, $F(1, 1186) = 7.16$, $p<.01$, eta square = .01, and solitude $F(1, 1186) = 5.08$, $p<.05$, eta square = .004, were all found to be significantly more negative in the Park Service rescue flight condition than in the tourist flight condition on those trials when helicopter noise was present.

Interestingly, the Park Service rescue flight condition was also found to be significantly different than the trail maintenance condition, $F(7, 1186) = 6.96$, $p<.001$, eta square = .04, and was found to be more negative on the landscape attributes of solitude, $F(1, 1186) = 24.48$, $p<.001$, eta square =.02, tranquility, $F(1, 1186) = 21.37$, $p<.001$, eta square =.02, overall preference, $F(1, 1186) = 10.49$, $p<.001$, eta square = .01, and freedom, $F(1, 1186) = 6.76$, $p<.01$. Finally, the tourist flight condition was found to be significantly different from the Park Service trail maintenance condition on those trials with helicopter noise, $F(7, 1180) = 6.71$, $p<.001$, eta square =.04. The tour flight condition was found to be significantly less positive on ratings of freedom, $F(1, 1192) = 11.82$, $p<.001$, eta square = .01, solitude, $F(1, 1192) = 8.38$, $p<.01$, eta square = .01, naturalness, $F(1, 1192) = 6.03$, $p<.05$, eta square = .005, and tranquility, $F(1, 1192) = 4.16$, $p<.05$, eta square = .004. Interestingly, scenic beauty was found to be significantly higher in the tourist flight condition when helicopter noise was present, $F(1, 1192) = 15.92$, $p<.001$, eta square = .01. These comparisons, although significant, were found to have small effect sizes, and should thus be interpreted with caution.

Another interesting comparison involves the landscape ratings when nature sounds were present, both in the control condition and the three noise conditions. In this regard, means and standard deviations for the seven dependent variables for the control condition and for the three helicopter noise conditions when only nature sounds were present are presented in Table 16. When examining these results, it becomes evident there appear to be differences between the conditions on the ratings of annoyance, suggesting that the presence of noise has lingering effects, at least with some attributes of the landscape. A MANOVA confirmed this assumption, finding a small but significant difference between the conditions when exclusively analyzing the nature trials, $F(21, 8846) = 2.94$, $p<.001$, eta square = .01.

Univariate analyses for this comparison can be found in Table 17. On those trials where nature sounds were present within the noise conditions, ratings of annoyance were significantly higher when compared to a control condition, $F(3, 2956) = 4.54$, $p<.01$, eta square = .02. Significant differences were also found between landscape ratings of scenic beauty, $F(3, 2956) = 4.40$, $p<.01$, eta square = .01, and naturalness $F(3, 2956) = 3.33$, $p<.05$, eta square = .01. These significant findings, however, should be viewed with

Table 16

Means and Standard Deviations for the Seven Dependent Scales

for the Control and Noise Conditions when Nature Sounds were Present

Condition	Annoyance	Freedom	Naturalness	Preference	Solitude	Tranquility	Scenic Beauty
Control							
M	2.1877	8.1759	8.6465	7.5939	7.9798	7.9519	8.3064
SD	1.8318	1.9376	1.8097	2.2844	2.1245	1.9587	1.8609
Tour Flight							
M	3.3049	8.2450	8.5570	7.6040	8.0654	7.9027	8.4597
SD	2.5785	1.9628	1.7340	2.3467	2.1383	2.3061	1.8141
NPS Rescue							
M	3.5219	8.1913	8.5352	7.7559	8.0101	8.1436	8.4111
SD	1.5965	1.7748	1.8499	2.1207	2.0563	1.8881	1.7625
NPS Trail Maint.							
M	3.5193	7.9731	8.3674	7.4334	7.9277	7.9005	8.1124
SD	2.2078	1.8079	1.6038	2.1188	1.9932	1.8550	1.7429

Table 17

Univariate Analyses of Variance Between Conditions on Trials when only Nature Sounds were Present

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Annoyance	43.692	9479.279	14.564	3.207	4.542	.004	.005
Freedom	24.794	10486.622	8.265	3.548	2.329	.073	
Naturalness	30.626	9053.146	10.209	3.063	3.333	.019	.003
Scenic Beauty	43.232	9671.513	14.411	3.271	4.404	.004	.004
Preference	31.633	14739.501	10.544	4.986	2.115	.096	
Solitude	6.610	12788.381	2.203	4.326	.509	.676	
Tranquility	23.680	11836.644	7.893	4.004	1.971	.116	

skeptism, as no effect size in either the multivariate or univariate analyses exceeded .02. Sample size, therefore, appears to be accounting for the differences, at least in this comparison.

Type of Environment

A variety of natural environments found throughout the southwestern U.S. were includedin the slide set of this investigation. All scenes were from national parks in this region and depicted such features as high mountain peaks, non-turbulent water features, forested landscapes, desert arches and canyons, and areas affected by uniform and layered haze. Overall means and standard deviations across all conditions for the different environment types are shown in Table 18. Scenic beauty, along with overall preference, have been the variables most often studied in previous landscape assessments. When examining the preference means for the different environment types used in this study, it becomes evident that non-turbulent water features and mountain peaks (M = 7.4 and 7.0 respectively) are the most highly preferred pristine settings. Univariate analyses confirm this assumption, with non-turbulent water features being preferred significantly more than mountain peak vistas, $F(1, 1572) = 10.14$, $p<.001$, eta square = .01. Water landscapes were also found to be significantly preferred over desert vistas, $F(1, 1571) = 68.75$, $p<.001$, eta square = .05. Non-turbulent water environments are thus preferred over all other environments depicted in this study. Mountain peaks were also found to be significantly preferred over desert vistas, $F(1, 1586) = 27.29$, $p<.001$, eta square = .02. These findings are consistent with previous research examining environment preference (e.g., Herzog, 1984, 1985, 1990; Hull & Stewart, 1995; Ulrich, 1993).

Table 18

Overall Means and Standard Deviations for the Different Environments on the Seven Dependent Scales

Environment	Preference	Scenic Beauty	Naturalness	Solitude	Tranquility	Freedom	Annoyance
Water							
M	7.4352	9.0677	8.4330	6.7196	6.9000	7.8159	2.8913
SD	2.7023	1.3329	2.0858	3.0508	3.1079	2.3452	3.4589
Mountain Peaks							
M	7.0088	8.7491	8.3363	6.7362	6.6633	7.5038	3.0263
SD	2.6105	1.5062	2.0655	3.0083	3.0202	2.4088	3.4952
Desert							
M	6.3077	8.1316	7.9599	6.5890	6.2302	7.2870	3.2343
SD	2.6890	1.8868	2.1895	2.8979	2.9146	2.3617	3.4180
Forest							
M	6.2053	7.7779	7.9121	6.3907	6.2377	7.0101	3.2085
SD	2.5822	1.9464	2.0874	2.8252	2.8625	2.3289	3.3352
Uniform - Clear							
M	6.3641	8.2036	7.9695	6.5954	6.2821	7.2494	3.1858
SD	2.5845	1.8209	2.1462	2.7961	2.8659	2.3165	3.4164
Uniform Haze							
M	5.5739	6.9275	7.2025	6.1875	5.9098	6.5525	3.3075
SD	2.6131	2.3066	2.3216	2.7158	2.7613	2.4804	3.1164
Layered - Clear							
M	6.1050	7.8150	7.6750	6.3125	6.2350	7.0475	3.3350
SD	2.5525	1.7843	2.0929	2.7411	2.8133	2.2767	3.3483
Layered Haze							
M	5.9395	7.7111	7.5251	6.4232	6.1411	6.9749	3.2487
SD	2.4856	1.8302	2.1466	2.7066	2.7460	2.3031	3.1862

Scenic beauty also showed a similar pattern with scenes depicting water and mountain peaks possessing the highest amount of scenic quality. Water environments were found to be significantly preferred over landscapes dominated by mountain peaks, $F(1, 1578) = 19.8$, $p<.001$, eta square = .01, and deserts, $F(1, 1579) = 129.38$, $p<.001$, eta square = .08, as well as every other environment included in this study. Mountain peaks were found to be significantly higher in scenic beauty than desert environments, $F(1, 1593) = 52.16$, $p<.001$, eta square =.03, as well as the remainder of the environmental sets. Preference and scenic beauty have been found to be highly correlated in previous research when different landscapes were being evaluated. In this study it appears that overall preference ratings are quite a bit higher than ratings of scenic beauty. Overall preference may be truncated more than scenic beauty because of the larger effect that helicopter noise was found to have on overall preference for the landscapes. This may be true of a couple of the other dependent measures as well, simply because scenic beauty produced the smallest effects when helicopter noise was present relative to the other six rating scales.

Differences also appear to be apparent between the landscapes containing uniform haze and the identical vistas without any visible air pollution on many of the landscape measures. Specifically, the presence of uniform haze appears to cause ratings of scenic beauty, naturalness, and overall preference to become more negative. This assumption was confirmed using univariate analyses of variance, with the presence of uniform haze causing a significant reduction in scenic beauty, $F(1, 791) = 74.60$, $p<.001$, eta square = .03, naturalness, $F(1, 791) = 23.31$, $p<.001$, eta square =.03, and overall preference for the environment, $F(1, 787) = 18.23$, $p<.001$, eta square = .02.

With these and other differences found between the dependent measures and the different natural environments, a mixed-model multivariate analysis of variance was conducted with environment (within-subjects) and source attribution (between-subjects) included as the independent variables. A significant interaction between environment and condition was not produced, $F(147, 32937) = 1.12$. However, univariate analyses did find significant interactions between condition and environment on annoyance, $F(21, 4713) = 5.53$, $p<.001$, eta square =.03, tranquility, $F(21, 4713) = 4.54$, $p<.001$, eta square = .02, solitude, $F(21, 4713) = 2.94$, $p<.001$, eta square = .01, and overall preference, $F(21, 4713) = 3.18$, $p<.001$, eta square = .01, although the effects are small. Although there was not a significant interaction between the four conditions and the type of environment, the four dependent measures that did reach significance are the four variables that were found to be the most negatively impacted by helicopter noise, regardless of the source. These univariate results should be interpreted cautiously, however, as the effect sizes were rather small, with none exceeding .02, and were not strong enough to produce a significant overall multivariate effect.

The Sounds of Nature, Helicopter Noise and Type of Environment

Based on results previously discussed regarding the main effect of the helicopter noise conditions and the univariate results just mentioned, post-hoc tests were conducted between the environments exposed to helicopter noise and those environments where only nature sounds were present. With only small differences being apparent between the conditions where helicopter noise was present and attributed to a different type of flight, it was believed that noise trials could be combined for the purposes of this analysis. Recall that the major differences between the conditions were found to exist between the control condition, exposed only to nature sounds, and the three helicopter noise conditions, exposed to both nature sounds and helicopter noise on an equal basis. Therefore, noise trials were combined between the three noise conditions and nature sound trials were combined between the control condition and the three noise conditions. Means for the different environments with and without helicopter noise for each of the seven dependent measures are presented in Table 19 broken down by type of environment. Differences appear to exist between most of the dependent variables in all of the different types of environments when helicopter noise was present compared to when nature sounds were present. In order to more directly test this assumption, analyses were conducted within each type of environment in order to ascertain if the mere presence of helicopter noise had an effect on how each specific type of environment was evaluated.

Environments depicting non-turbulent water features were found to be the most preferred of all the types of landscapes, and when helicopter noise was present in this type of environment, landscape ratings became significantly more negative, according to MANOVA, $F(7, 770) = 265.98$, $p<.001$, eta square = .71. Post-hoc univariate analyses were conducted in order to examine the individual landscape measures within the depicted water environments. These results are presented in Table 20. Previous research has primarily focused on scenic beauty and overall preference when landscape assessments have been conducted. These studies have traditionally focused on visual properties of the environment and have not included nature sounds or noise. Of specific interest in this study, therefore, are the effects of helicopter noise on these specific landscape variables. Overall preference for water environments was found to deteriorate

Table 19

Means for the Different Environments on the Seven Dependent Scales on Trials when Helicopter Noise is either Present or Not

Environment	Preference	Scenic Beauty	Naturalness	Solitude	Tranquility	Freedom	Annoyance
Water							
Noise	5.0102	8.7441	7.2290	3.9424	3.7797	6.0404	6.5034
Nature	8.9132	9.2654	9.1687	8.4053	8.7979	8.9031	0.6914
Mountain Peaks							
Noise	4.9732	8.4214	7.3244	4.0936	3.7592	5.8322	6.7191
Nature	8.2359	8.9458	8.9438	8.3260	8.4105	8.5040	0.8092
Desert							
Noise	4.4314	7.7826	6.9833	4.0268	3.5753	5.7324	6.7358
Nature	7.4433	8.3047	8.5451	8.1242	7.8306	8.2184	1.1363
Forest							
Noise	4.4047	7.4833	6.9465	4.0702	3.7324	5.5987	6.5017
Nature	7.2929	7.9557	8.4390	7.7867	7.7480	7.8592	1.2274
Uniform - Clear							
Noise	4.9862	8.3655	7.2966	4.3655	4.0000	5.9586	6.5517
Nature	7.1796	8.1089	8.3629	7.8992	7.6327	8.0040	1.2177
Uniform Haze							
Noise	4.2000	6.7000	6.2667	4.1200	3.6000	5.2733	6.2800
Nature	6.4016	7.0640	7.7640	7.4280	7.3012	7.3200	1.5240
Layered - Clear							
Noise	4.4333	7.6533	6.8400	4.0200	3.7600	5.6667	6.7200
Nature	7.1080	7.9120	8.1760	7.6880	7.7200	7.8760	1.3040
Layered Haze							
Noise	4.5772	7.6000	6.6867	4.4094	3.9664	5.7800	6.1467
Nature	6.7581	7.7782	8.0323	7.6331	7.4476	7.6976	1.4960

significantly when helicopter noise was present, F(1, 776) = 748.76, p<.001, eta square = .49. Scenic beauty of water environments was also found to be significantly diminished when helicopter noise was present, F(1, 776) = 29.68, p<.001, eta square = .04. Perceived naturalness of the depicted water environments also significantly declined when helicopter noise was present, F(1, 776) = 207.10, p<.001, eta square = .21. While these are the main variables of interest within the landscape assessment literature, it also interesting to note the significant differences on the remaining dependent variables. Landscapes showing mountain peaks were also found to be a highly preferred type of environment in this study and in previous research. A MANOVA found significant differences in this type of environment when helicopter noise was present, F(7, 786) = 256.72, p<.001, eta square = .70. Univariate analyses are presented in Table 21, and show significantly lower preference for the mountain environments, F(1, 792) = 460.66, p<.001, eta square = .37, as well as a reduction in scenic beauty, F(1, 792) = 23.78, p<.001, eta square = .03. Perceived naturalness of the mountain landscapes was found to significantly differ when helicopter noise was present compared to background nature sounds, F(1, 792) = 135.20, p<.001, eta square = .15. As found in the water environments, all other dependent landscape measures were found to become significantly more negative when helicopter noise was present.

Forest environments were also examined with and without the presence of helicopter noise. Forests were found to be rated significantly more negative, as analyzed with MANOVA, when helicopter noise was present, F(7, 786) = 182.667, p<.001, eta square = .62. Table 22 depicts the univariate follow-up analyses for the forest landscapes, again showing significant differences in ratings of overall preference,

Table 20

Univariate Analyses of Variance for the Effect of Helicopter Noise on Non-Turbulent Water Landscape Ratings

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Preference	2786.7481	2888.1413	2786.7481	3.7218	748.757	<.001	.491
Scenic Beauty	50.7116	1325.8141	50.7116	1.7085	29.681	<.001	.037
Naturalness	704.4853	2639.6381	704.4853	3.4016	207.104	<.001	.211
Freedom	1521.7340	2761.0733	1521.7340	3.5581	427.683	<.001	.355
Solitude	3668.9343	3561.5400	3668.9343	4.5896	799.399	<.001	.507
Tranquility	4610.5634	2902.7939	4610.5634	3.7407	1232.536	<.001	.614
Annoyance	6180.9749	3128.0032	6180.9749	4.0309	1533.386	<.001	.664

Table 21

Univariate Analyses of Variance for the Effect of Helicopter Noise on Landscape Ratings of Mountain Peaks

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Preference	1989.8726	3421.0656	1989.8726	4.3195	460.669	<.001	.368
Scenic Beauty	52.5824	1751.0398	52.5824	2.2109	23.783	<.001	.029
Naturalness	494.6762	2897.8792	494.6762	3.6589	135.197	<.001	.146
Freedom	1336.9304	3273.5382	1336.9304	4.1333	323.457	<.001	.290
Solitude	3341.4108	3845.1433	3341.4108	4.8548	688.244	<.001	.465
Tranqility	4030.1859	3212.7008	4030.1859	4.0564	993.528	<.001	.556
Annoyance	6499.8295	3197.4451	6499.8295	4.0372	1609.993	<.001	.670

Table 22

Univariate Analyses of Variance for the Effect of Helicopter Noise on Landscape Ratings of Forest Dominant Environments

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Preference	1554.9791	3732.5587	1554.9791	4.7128	329.946	<.001	.294
Scenic Beauty	42.7128	2964.0277	42.7128	3.7425	11.413	<.001	.014
Naturalness	444.6181	3014.8529	444.6181	3.8066	116.801	<.001	.129
Freedom	953.7170	3357.2213	953.7170	4.2389	224.991	<.001	.221
Solitude	2573.4724	3766.8261	2573.4724	4.7561	541.090	<.001	.406
Tranquility	3004.9288	3498.0297	3004.9288	4.4167	680.355	<.001	.462
Annoyance	5175.7086	3647.0320	5175.7086	4.6048	1123.972	<.001	.587

$F(1,792) = 329.95$, $p<.001$, eta square = .29, scenic beauty $F(1, 792) = 11.41$, $p<.001$, eta square = .01, and naturalness, $F(1, 792) = 116.80$, $p<.001$, eta square =.13, when helicopter noise was present in the depicted scene. Forest environments also provided less solitude, tranquility, and freedom when helicopter noise was present.

Environments containing desert arches and canyons were also subjected to analysis with the presence or absence of helicopter noise. Landscape evaluation of the desert landscapes became significantly more negative when helicopter noise was present, once again using MANOVA, $F(7, 785) = 233.21$, $p<.001$, eta square = .68. Univariate analyses can be found in Table 23, showing significantly more negative ratings of overall preference for the desert environment, $F(1, 791) = 331.05$, $p<.001$, eta square = .30, scenic beauty of the arches and canyons, $F(1, 791) = 17.57$, $p<.001$, eta square = .02, and perceived naturalness, $F(1, 791) = 112.08$, $p<.001$, eta square = .12. The remaining four landscape rating scales were also found to be negatively affected by the presence of helicopter noise in the desert environments portrayed in this study.

Air Pollution and Helicopter Noise

Two different types of haze were included in the slide set in this study. Uniform and layered haze were added into pristine desert vistas of the Grand Canyon and Bryce Canyon National Parks. In both instances, haze was digitally added using a computer and a matrix slide writer with the assistance of the Cooperative Institute for Research on the Atmosphere, a research division of the National Park Service and Department of Interior. Both types of haze were included in this study, along with the same environments with the exact terrestrial features in the same locations without any visible air pollution present. Helicopter noise was also

Table 23

Univariate Analyses of Variance for the Effect of Helicopter Noise on Ratings of Desert Landscapes

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Preference	1689.6656	4037.2574	1689.6656	5.1039	331.049	<.001	.295
Scenic Beauty	61.2977	2760.1651	61.2977	3.4895	17.567	<.001	.022
Naturalness	467.0617	3296.2119	467.0617	4.1672	112.082	<.001	.124
Freedom	1164.4672	3258.8241	1164.4672	4.1199	282.646	<.001	.263
Solitude	3166.3609	3456.7009	3166.3609	4.3700	724.561	<.001	.478
Tranquility	3378.2417	3357.4455	3378.2417	4.2446	795.899	<.001	.502
Annoyance	5837.2938	3440.7678	5837.2938	4.3499	1341.939	<.001	.629

included in these environments, as both Grand Canyon and Bryce Canyon National Parks experience aircraft overflights on a daily basis. With this design, comparisons can be made between the presence or absence of uniform and layered haze, the presence or absence of helicopter noise, and any interaction between the two ambient environmental stressors.

MANOVA was used to analyze this interaction as well as the main effects for uniform haze and helicopter noise. A significant interaction between the two ambient stressors was not realized, although the interaction approached significance, $F(7, 779) = 1.95$, $p = .059$. However, main effects for both uniform haze and helicopter noise were produced. As uniform haze increased, landscape ratings as to the quality of the environment significantly declined, $F(7, 779) = 12.22$, $p<.001$, eta square = .10. Similarly, when helicopter noise was present, landscape ratings also became significantly more negative, $F(7, 779) = 171.28$, $p<.001$, eta square = .61.

Univariate analyses of variance were conducted for each of the significant main effects. Table 24 illustrates the main effect for uniform haze in the Desertview Point vistas in the Grand Canyon on the seven dependent landscape measures. When uniform haze was present in the Desertview slides, ratings of scenic beauty, $F(1,785) = 79.74$, $p<.001$, eta square = .09, naturalness, $F(1, 785) = 28.26$, $p<.001$, eta square = .04, freedom, $F(1, 785) = 18.94$, $p<.001$, eta square = .02, and overall preference, $F(1, 785) = 20.04$, $p<.001$, eta square = .02, all significantly declined. Scenic beauty has been extensively studied and was found to produce the largest effect in this study with regard to uniform haze, eta square =.09. Uniform haze, therefore, appears to have a detrimental effect on the quality of the landscape, at least at Desertview Point, Arizona.

Table 24

Univariate Analyses of Variance for the Main Effect of Uniform Haze on Landscape Ratings of Desertview Point, Arizona

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Preference	112.9545	4423.9097	112.9545	5.6356	20.043	<.001	.024
Scenic Beauty	344.5435	3391.9199	344.5435	4.3209	79.739	<.001	.092
Naturalness	128.8735	3580.2338	128.8735	4.5608	28.257	<.001	.035
Freedom	90.5724	3753.2196	90.5724	4.7812	18.944	<.001	.023
Solitude	25.4399	3811.1652	25.4399	4.8549	5.239	.022	.007
Tranquility	24.6996	3745.3484	24.6996	4.7711	5.177	.023	.007
Annoyance	0.1802	3700.7221	.1802	4.7143	0.038	.845	

Helicopter noise also produced a significant main effect in the Desertview landscapes. For this reason, univariate analyses were conducted in order to determine which of the seven dependent measures were accounting for the significant differences. Univariate analyses of variance can be found in Table 25. As would be expected, annoyance was found to differ to the greatest extent when helicopter noise was present compared to when nature sounds were present in the Desertview landscapes. Annoyance levels greatly increased on those trials with helicopter noise, $F(1, 785) = 1000.09$, $p<.001$, eta square =.56. Tranquility, $F(1,785) = 520.03$, $p<.001$, eta square =.39, and solitude, $F(1, 785) = 448.89$, $p<.001$, eta square =.36, were also significantly affected by the presence of helicopter noise, with ratings of each measure becoming much more negative. The remaining dependent measures also reached significance except for scenic beauty, which was not affected by the presence of helicopter noise in the Desertview landscapes. Overall preference for the depicted environment was also impacted by the presence of helicopter noise, which has implications for how landscape assessments are conducted in the future.

Layered haze was included in landscapes depicting a scenic vista of Bryce Canyon National Park in Utah. MANOVA was used to assess the interaction of helicopter noise with the presence of layered haze in this environment. A significant interaction between these two ambient stressors was not realized in this study, $F(7, 787) = 1.07$. Likewise, the presence of layered haze in the depicted environments did not produce a significant main effect, $F(7, 787) = 1.77$. Helicopter noise, however, was found to have a significant effect on landscape ratings of Bryce Canyon, $F(7, 787) = 162.99$, $p<.001$, eta square = .59. Univariate analyses of variance were conducted in

Table 25

Univariate Analyses of Variance for the Effect of Helicopter

Noise on Landscape Ratings of Scenic Vistas of Desertview Point, Arizona

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Preference	891.7421	4423.9097	891.7421	5.6356	158.235	<.001	.168
Scenic Beauty	0.7725	3391.9199	0.7725	4.3209	0.178	.673	
Naturalness	309.1418	3580.2338	309.1418	4.5608	67.782	<.001	.079
Freedom	782.8691	3753.2196	782.8691	4.7811	163.740	<.001	.173
Solitude	2179.3614	3811.1652	2179.3614	4.8549	448.891	<.001	.364
Tranquilty	2483.0655	3745.3484	2483.0655	4.7711	520.434	<.001	.399
Annoyance	4714.7073	3700.7220	4714.7073	4.7143	1000.087	<.001	.560

order to break down the significant main effect for the presence of helicopter noise with results presented in Table 26. Similar to the results obtained with the Desertview landscapes, depictions of Bryce Canyon were strongly affected by helicopter noise with regard to level of annoyance, $F(1, 793) = 1004.81$, $p<.001$, eta square = .56, tranquility, $F(1, 793) = 578.36$, $p<.001$, .42, and solitude, $F(1, 793) = 479.30$, $p<.001$, eta square = .38. All landscape measures were affected by the presence of helicopter noise in the Bryce Canyon vistas with the exception of scenic beauty. Overall preference and naturalness significantly declined as a result of helicopter noise, which again raises methodological concerns when landscape assessments are conducted without auditory stimuli.

In sum, all environments used in this study were negatively affected by the presence of helicopter noise. As would be expected, annoyance was the variable most strongly affected by the noise, but was certainly not the only factor that was negatively impacted. In many of the landscapes used in this study, all of the dependent landscape measures were negatively affected by the presence of helicopter noise. This suggests that many distinct types of natural environments are affected by the presence of helicopter noise.

Positive and Negative Affect

Affective reaction to the experimental conditions was assessed using the PANAS measure (Watson et al., 1988). Positive and negative affect are differentiated from one another using subscales within this instrument, thereby producing independent scores for positive and negative affect. These affective states were measured using a pre-post design in all four conditions of the present study.

Table 26

Univariate Analyses of Variance for the Effect of Helicopter Noise on Landscape Ratings of Bryce Canyon, Utah

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Signif. of F	eta-square
Preference	1101.1676	3932.7636	1101.1676	4.9594	222.039	<.001	.219
Scenic Beauty	9.0249	2590.6789	9.0249	3.2669	2.763	.097	.003
Naturalness	331.3611	3233.1646	331.3611	4.0771	81.273	<.001	.093
Freedom	790.8779	3369.3582	790.8779	4.2489	186.138	<.001	.191
Solitude	2218.3257	3670.2397	2218.3257	4.6283	479.296	<.001	.377
Tranquility	2586.1591	3545.9108	2586.1591	4.4715	578.363	<.001	.422
Annoyance	4727.7709	3731.1722	4727.7709	4.7051	1004.811	<.001	.559

Figure 1 depicts the means for positive and negative affect in the control condition, exposed only to background nature sounds. As seen in this figure, positive affect is nearly identical prior to and following exposure to natural stimuli. Paired samples t-tests confirmed this assumption, showing no significant difference or change in positive affect in the control condition as a result of exposure to the natural environments, t(49) = .61. Negative affect, however, was significantly affected by the scenic landscapes and sounds, becoming less negative following the natural landscape assessment, t(49) = 3.26, $p<.01$, $R^2 = .18$. With a reduction in negative affect, this suggests a potential restorative function of the natural stimuli, something that has been found in numerous natural landscape studies in the past (e.g., Ulrich, 1993).

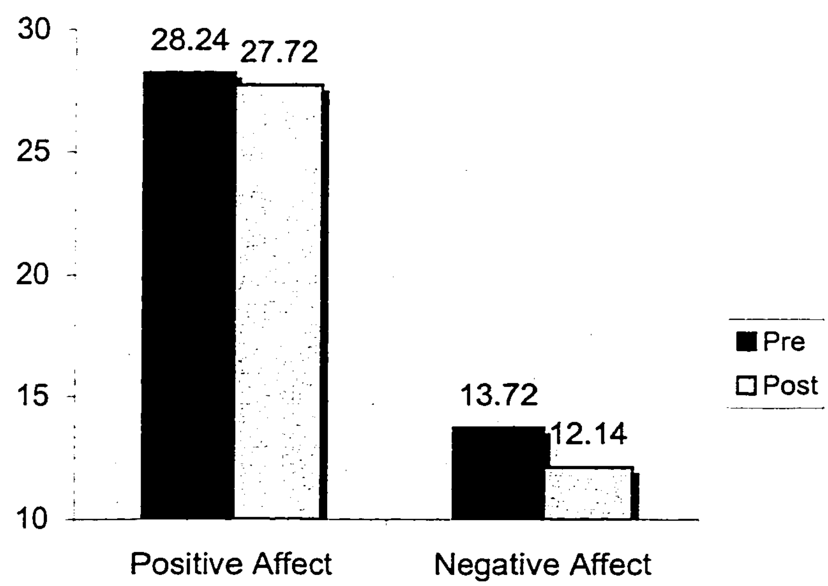

Figure 1. Means for positive and negative affect in the control condition.

In the condition in which helicopter noise was attributed to a tourist overflight, positive and negative affect were found to be affected by the presence of helicopter noise. Figure 2 illustrates the means for positive and negative affect prior to and following exposure to helicopter noise. As seen in this figure, positive affect drops slightly after the landscape assessment, t(49) = - 2.45, $p<.05$, $R^2 = .11$. Helicopter noise attributed to a tourist flight caused a significant increase in negative affective state, t(49) = 3.07, $p<.01$, $R^2 = .16$. Overall, then, in the tourist flight condition, helicopter noise attributed to a tourist flight had a significant effect on an individual's affective state.

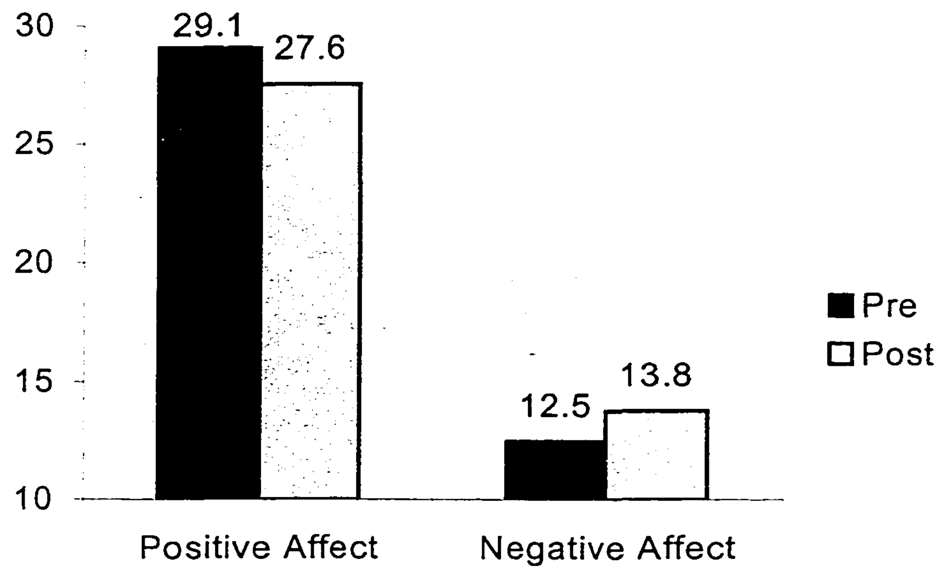

Figure 2. Means for positive and negative affect in the helicopter tourist flight condition.

Results were found to be similar in the helicopter rescue noise condition. Both positive and negative affect were slightly but significantly affected by helicopter noise attributed to a Park Service rescue flight. Figure 3 depicts the calculated means for positive and negative affect for the pre and post measures for the rescue condition. Positive affective state significantly decreased following exposure to helicopter noise attributed to a Park Service rescue flight, $t(49) = -2.01$, $p<.05$, $R^2 = .08$. Negative affect significantly increased when helicopter noise was present in this condition, $t(49) = 2.06$, $p<.05$, $R^2 = .08$.

Noise attributed to an NPS backcountry trail maintenance flight also had an effect on positive affect; however, negative affect was not significantly changed in this condition, $t(49) = 1.2$. Positive affect slightly but significantly dropped following exposure to helicopter noise in the trail maintenance condition, $t(49) = -3.35$, $p<.01$, $R^2 =.19$. Overall, then, it appears that exposure to helicopter noise, whatever the source, had a significant negative effect on positive affective state. Negative affect was also significantly increased by helicopter noise attributed to a tourist flight or the Park Service

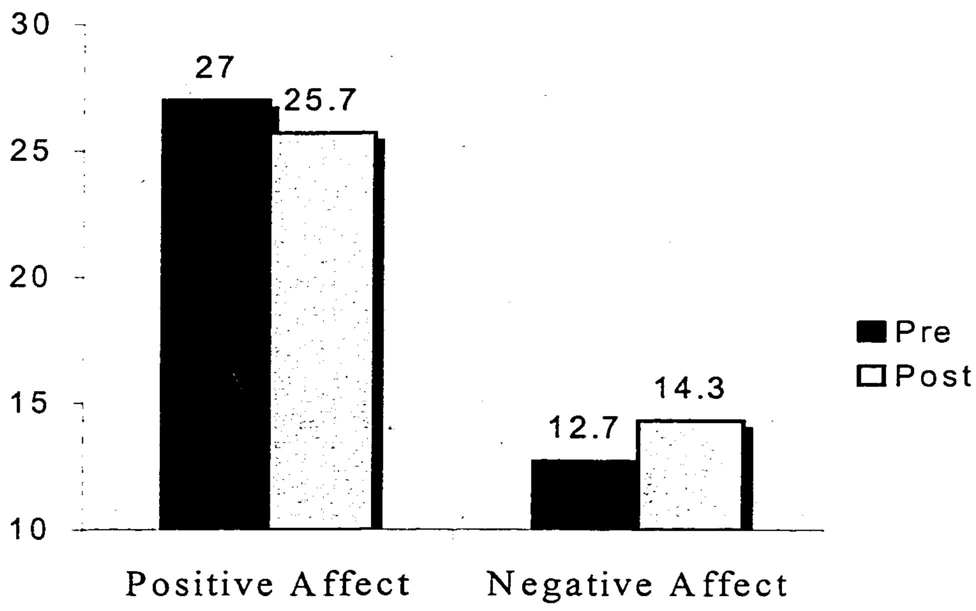

Figure 3. Means for positive and negative affect in the NPS helicopter rescue condition.

performing a rescue flight, but was not significantly impacted by noise attributed to trail maintenance flights.

The four different conditions were analyzed for differences between them on positive and negative affect both prior to and following exposure to the landscape ratings. Differences were found to exist between the control condition and the tourist flight condition, with negative affect being significantly more negative in the tourist flight condition, $t(98) = 2.61$, $p<.01$, $R^2 =.07$. Those in the rescue condition were also found to be in a significantly more negative affective state than those in the control condition following exposure to the experimental procedures, $t(98) = 2.47$, $p<.05$, $R^2 = .06$. Park Service flight activities for trail maintenance differed significantly on both positive and negative affect when compared to the control condition. Specifically, following exposure to helicopter noise, positive affect became more negative, $t(98) = 2.18$, $p<.05$, $R^2 = .05$, while negative affect significantly increased, $t(98) = 2.0$, $p<.05$, $R^2 = .04$. No other comparisons between the four conditions were found to be significant at the .05 level with regard to positive and negative affect. It appears, however, that exposure to helicopter noise, whatever its source, causes a negative affective reaction. These results raise important consequences for the visitor as well as the federal land manager that will be discussed in more depth in the next chapter.

Multiple Regression Analysis

With high correlations between the dependent variables apparent, linear multiple regression was used in the four conditions to examine how the dependent measures relate to overall preference for the natural landscapes. Therefore, preference was used as the dependent variable in all of the following regression equations, with the other six measures loaded into the analysis as the predictors.

In the control condition, regression predictors were loaded simultaneously in a linear fashion, and produced an adjusted $\underline{R}^2$ of .74. Table 27 depicts a summary of the multiple regression analysis for variables predicting overall preference for natural environments with only background nature sounds present. Based on the obtained beta weights, it appears that tranquility and scenic beauty were the largest predictors of preference within the control condition. Annoyance, freedom, and naturalness also contributed to the prediction of overall preference for the natural environments represented in this study. Interestingly, although a strong beta result was found for tranquility, the dimension of solitude within the control condition contributed little to the prediction of overall preference for the natural landscapes and nature sounds.

Multiple linear regression was used with the same model in the helicopter tour flight noise condition in order to ascertain what effects noise had on the prediction of preference for natural landscapes. With preference as the dependent variable and the other six landscape measures used as predictors, a large multiple correlation was found, $\underline{R}^2 = .69$. A summary of this analysis is provided in Table 28. As found in the control condition, tranquility and scenic beauty contributed strongly to the prediction of overall preference in the tourist flight noise condition. Freedom, annoyance, and solitude were also found to significantly contribute to the prediction of overall preference in this condition.

Multiple regression analysis was also used in the NPS rescue flight noise condition, again using overall preference as the dependent measure and the other six

Table 27

Summary of Multiple Regression Analysis for Variables Predicting

Overall Preference for Natural Environments in the Control Condition

Variable	B	SE B	R^2
Scenic Beauty	.449	.029	.366*
Naturalness	.125	.027	.099*
Freedom	.152	.029	.129*
Annoyance	.181	.023	.145*
Solitude	.019	.023	.017
Tranquility	.497	.032	.426*

*$\underline{p}$ <.001

Table 28

Summary of Multiple Regression Analysis for Variables Predicting Overall Preference for Natural Environments in the Helicopter Tour Flight Noise Condition

Variable	B	SE B	R^2
Scenic Beauty	.401	.027	.282*
Naturalness	.016	.028	.015
Freedom	.213	.031	.206*
Annoyance	.107	.021	.145*
Solitude	.114	.034	.126*
Tranquility	.273	.031	.311*

*p <.001

landscape scales as predictors. This model was found to account for 78% of the variance based on the adjusted R-squared statistic. Table 29 shows the summary statistics for the multiple regression analysis in the NPS rescue flight condition. As can be seen in this table, tranquility once again plays a large role in the prediction of overall preference. Attributes of freedom and scenic beauty also greatly contribute to overall landscape preference. Solitude and annoyance, however, were found to contribute only slightly to the prediction of overall preference for the different environments rated in the NPS rescue flight condition.

Finally, the NPS backcountry trail maintenance noise condition was also analyzed in the same manner as the other three conditions. Using the same model, the predictors accounted for 75% of the variance in the prediction of overall preference for the environments in this condition. A summary of the predictors and associated statistics can be found in Table 30. Interestingly, all six predictors were found to significantly contribute to the prediction of overall preference for the natural landscapes, although two of these predictors were at different alpha levels of significance. Tranquility, once again, and scenic beauty were found to strongly predict overall preference. Similarly, freedom and solitude were also found to greatly contribute to landscape preference in the NPS backcountry maintenance condition. Naturalness and annoyance also played a significant role in the prediction of preference, at least in this condition.

Overall it appears that the measures chosen for use in this study are strongly related to the prediction of landscape preference. Variance accounted for ranged from .69 to .78 in the four conditions of this study.

Table 29

Summary of Multiple Regression Analysis for Variables Predicting Overall Preference for Natural Environments in the NPS Rescue Flight Noise Condition

Variable	B	SE B	R^2
Scenic Beauty	.223	.026	.150*
Naturalness	.017	.027	.013
Freedom	.289	.028	.252*
Annoyance	.018	.020	.023
Solitude	.013	.026	.014
Tranquility	.504	.031	.564*

*p <.001

Table 30

Summary of Multiple Regression Analysis for Variables Predicting Overall Preference for Natural Environments in the NPS Backcountry Maintenance Noise Condition

Variable	B	SE B	R^2
Scenic Beauty	.323	.027	.232***
Naturalness	.067	.028	.051**
Freedom	.168	.028	.146***
Annoyance	.053	.019	.069*
Solitude	.131	.028	.141***
Tranquility	.386	.029	.422***

*$p<.01$
**$p<.05$
***$p <.001$

Chapter IV

Discussion

One of the main interests of this study had to do with the source attribution of helicopter noise and its associated effects on natural landscape ratings. Based on the results of this study and previous research (e.g., Mace, 1997; Mace et al., 1999) it can be stated that helicopter noise, whatever its source, interferes with important attributes and experiences that natural environments provide. This is especially important when considering that the primary reasons for visiting natural environments include the attainment of tranquility and solitude and escaping from the stressors of the urban world (Driver et al., 1987). Although subtle differences did emerge between helicopter noise conditions in the present study, when compared to a control group the noise conditions were much more similar to one another than different. In other words, the mere presence of helicopter noise appears to trigger an important reaction, whether the source of the noise is attributed to a tourist overflight, an NPS rescue flight, or an NPS backcountry trail maintenance flight.

It was hypothesized there would be a rank order with regard to the three noise conditions, with participants being most annoyed in the tourist flight condition, and successively less annoyed in the NPS trail maintenance and NPS rescue flight conditions. It was believed the rescue flight would be tolerated as participants would empathize with the victim and put up with the noise as it signaled that rescue was on the way. This, however, did not turn out to be the case, as the differences in annoyance between the noise conditions were not great enough to reach statistical significance. Furthermore, the rescue flight was found to significantly differ from the tourist flight condition only on ratings of scenic beauty, and significantly differed from the NPS trail maintenance condition only on the landscape attributes of scenic beauty and solitude. These effects were very small and represent very subtle differences between the three noise conditions.

It could be that participants do not identify themselves with the victim in need of a rescue, and are, in fact, annoyed that the rescue has to take place at all. One possible explanation is that participants in this study are placing the blame on the victim as opposed to the environment or the situation, and thus feel the individual being rescued is at fault by going into the backcountry unprepared. With an increase in visitation throughout the national park system in the last decade, more and more backcountry rescues have been conducted in recent years, especially in the more heavily visited locations such as the Grand Canyon and the most dangerous locations such as Denali.

With an increase in rescue flights over the last few years, media attention has focused on this management issue and has raised the question of who should pay for such rescue flights. Participants in this study felt overwhelmingly that the individuals being rescued should pay the bill for the flight and associated costs, with 84% stating they agreed or strongly agreed that visitors who need to be rescued from the backcountry should be responsible for the costs of that rescue. It seems there is little empathizing with the person in need of the rescue; instead, it appears that the victim is blamed for being unprepared or exercising poor judgement and is, therefore, responsible for the noise of the helicopter rescue, as well as the financial cost of the Park Service providing it.

Further study of this specific issue is needed in a timely manner, especially if visitation continues to increase.

Backcountry flight operations for the purpose of building and maintaining trails was included in this study because of the timeliness of the issue in many of the national parks. Controversies have arisen lately focusing primarily on the issue of helicopter overflights carrying tourists on scenic journeys, with only a small amount of attention being focused on the other activities where the use of helicopters has become commonplace. For example, in Rocky Mountain National Park in Colorado, helicopter overflights have recently been banned for scenic tours. However, the Park Service is still allowed to use helicopters for rescue and backcountry maintenance flights in Rocky Mountain National Park. Those individuals whose livelihood is tied directly to the overflight industry find this approach rather hypocritical and exclusionary. Why is the Park Service allowed to fly helicopters within the park boundaries when tourist companies are not, especially if the reaction to the noise by those on the ground is nearly identical? With an increase in visitation continuing in the national parks throughout the U.S., and these visitors bringing with them different expectations and recreational motives, this issue is one that is not going to disappear in the near future.

The use of helicopters for trail maintenance and construction has been an integral part of building the infrastructure of the backcountry in many national parks and monuments for years. The use of the helicopter for these activities has significantly reduced the burden of transporting materials over long distances and through rugged terrain, and, as the Park Service argues, tremendously reduces damage to the land. It has also allowed many national parks, underfunded and understaffed for decades, the ability to maintain and construct impressive trail systems, and to operate with fewer personnel and reduced costs, often on a shoestring budget. While the use of the helicopter for these types of activities may cause less damage to resources on the ground, it appears that the noise produced by the helicopter significantly detracts from another resource, namely natural quiet. When natural quiet is interfered with, positive attributes of the landscape become significantly more negative, as found in this study. Annoyance is increased, and landscape ratings of solitude, tranquility, naturalness, freedom, overall preference, and scenic beauty all deteriorate. These are attributes the Park Service is in charge of managing, and when Park Service activities detract from these important attributes, the activities of the Park Service, not just the visitors, need to be addressed. It becomes an issue of trade-offs, in terms of what types of activities the parks should allow themselves and their visitors to engage in when visiting and managing a given natural area. While this study illustrates some interesting findings regarding this issue, more research is needed before any sound conclusions and management directives can be implemented. This is an area where the valuation approaches may be of some use (Peterson, Brown, McCollum, Bell, Birjulin, & Clarke, 1994; Peterson, Driver, & Gregory, 1988).

The national parks are not the only natural land areas to be impacted by helicopters used for trail building and maintenance activities. For example, the U.S. Forest Service of the Department of Agriculture, an organization charged with managing vast expanses of wilderness areas, has recently proposed using helicopters for hauling in equipment and materials to build trails on 35, 14,000-foot peaks in Colorado (Finley, 1999). This example illustrates the need for helicopter noise to be studied in other natural environments. With the significant effects caused by helicopter noise in this study examining national park vistas, the question arises as to the applicability of these findings with regard to other natural environments. Are there differences between the effects of helicopters in wilderness areas, national parks, and state or regional parks? These are questions which future research needs to address.

Helicopter overflights for tourist purposes have received a great deal of attention in recent years from a multitude of individuals, organizations, and entities. Helicopter noise directly attributed to tourist overflights caused a strong, significant increase in level of annoyance in this study. Furthermore, all other landscape ratings were found to significantly decrease as a result of exposure to approximately 8 minutes of tourist flight helicopter noise. It is important to note that in all conditions where noise exposure was present, it was amplified at a loudness no greater than 60 dB(A), a level significantly below encounters that typically occur in the most affected national parks. Moreover, the exposure rate in this study was below what would typically occur in the same time period in certain locations along the south rim of the Grand Canyon, or in regions of Hawaii, for example. This was designed in such a fashion to be consistent with the other noise attribution conditions, where the exposure rate used in this study would be consistent with usual conditions when these activities occur.

One question that arises is the issue of external validity with regard to the findings of this study. While there are no direct on-site data currently available measuring annoyance in a similar manner as this study, there is evidence from the most heavily affected areas, such as the Grand Canyon, that helicopter noise from tourist flights is causing a large enough reaction, often negative, to inspire legislation specifically addressing the issue. The National Parks Overflights Act of 1987 gave unequivocal authority to the Secretary of the Interior to establish an aircraft management plan and to restore and protect natural quiet. In 1997, Congress renewed this act and further directly stated in the text of the act, "noise associated with aircraft overflights at a national park can cause a significant adverse effect on the natural quiet and experience of the park," a statement supported by the results of this study. The updated version of the National Parks Overflight Act (1987, 1997) also suggests changes in management and regulation through such measures as flight-free zones, flight restrictions, flight bans and the use of quiet aircraft technology. Finally, the Overflight Act directs the Federal Aviation Administration (FAA) to implement and enforce recommendations made by the National Park Service and the Department of the Interior regarding aircraft overflights.

During the 10 years between the Overflight Acts, it is interesting to note the increase in the number of helicopter tours in the park which helped to inspire the original legislation, namely the Grand Canyon. Helicopter tours have increased from approximately 40,000 in 1987 to 95,000 in 1996 (Kanamine, 1997) , to approximately 144,000 between April 1997 to March 1998 (Graham, 1999). Helicopter tour flights serve more than 800,000 tourists a year in Grand Canyon. The increase in traffic in the airspace above the canyon has significantly reduced the natural quiet of the park during the decade in which the quiet was to be restored. This illustrates a case of how slow implementation of a piece of legislation can be when the issue lacks sound research, is poorly understood, and has multiple interests and organizations involved. While legislation may be drafted to address an important issue, that does not always mean enforcement of the provisions of the act are a foregone conclusion. This was a problem that plagued the implementation of the first Overflight Act and led to much animosity between the Park Service and the FAA. NPS accused the FAA of consistently underestimating the number of tourist flights and of creating their own definition of natural quiet and noise modeling (Robinson, 1997). NPS also felt that the FAA on numerous occasions failed to implement changes suggested by NPS, despite the clear authority of NPS as described in the 1987 Overflights Act (Robinson, 1997). It is yet to be determined if the updated version of the Overflights Act (1997) will have any effect on this division between federal organizations and the implementation of a sound management plan.

With the discrepancies between organizations, numerous lawsuits have resulted from a variety of entities revolving around the airtour issue in Grand Canyon. For example, a coalition of the air tour industry took the FAA to federal court claiming changes were occurring too rapidly in regulations over the Grand Canyon. On the other side, a lawsuit was filed by the Grand Canyon Trust and the Wilderness Society claiming the FAA was moving too slowly. The lawsuits ended up in the U. S. Supreme Court, who recently ruled (as reported by Graham, 1999), without comment, that the government does not have to act faster to reduce aircraft noise in the Grand Canyon. The FAA estimates that if regulations suggested by the NPS in the Grand Canyon were put into effect, the goals of the Overflight Act of 1987 would be reached by the year 2008.

The increase in overflights in the Grand Canyon can be argued to merely reflect the increase in visitation that has been seen throughout the park system in recent years. If the increases in visitation that have occurred over the past decade continue into coming years in the Grand Canyon and throughout the park system, issues such as aircraft overflights and the noise they produce will remain important and become an issue of contention at many other national parks not currently overly impacted by overflights. While a great deal of this discussion has focused on the Grand Canyon, it is important to realize that many units of the park system are affected by helicopter overflight noise. The NPS estimates 150 individual units to be affected in some way by aircraft overflight noise. Many of the affected areas are located in the southwestern region of the U.S., and include such parks as Bryce Canyon, Canyonlands, and Arches, landscapes which were included in this study. Results found these landscapes to be negatively affected by the presence of helicopter noise attributed to a tourist flight. While these parks are yet to be impacted by overflights on the scale of Grand Canyon, models used in the management of the canyon can possibly be implemented in the developing parks with a proactive approach as opposed to a reactionary approach. Whether or not this becomes a reality as a result of the 1997 Overflights Act and the Supreme Court decision is yet to be determined. Suffice it to say that noise research is needed in a variety of natural environments, including those managed by the Park Service as well as other land management agencies.

It is interesting to note that those in the three noise conditions showed marked differences in landscape assessments between slides accompanied by noise and those accompanied by natural sounds. This was not true of annoyance, however, which was found to be significantly higher in all comparisons with the control group, both during and after helicopter noise exposure. It appears, therefore, that while measures of landscape quality, such as scenic beauty and overall preference, may rebound fairly rapidly after the helicopter noise dissipates, the effects do not completely extinguish, as appears to be true of affect as well. When helicopter noise was presented for eight minutes and attributed to a tourist overflight, positive affect declined while negative affect increased, as measured with the PANAS. This shows that exposure to helicopter noise attributed to a tourist flight does have an impact on mood, which would certainly have an effect on the visitor's experience at the time and possibly when recalled in the future, as addressed by McDonald, Baumgartner, and Iachan, (1995). These researchers found that visitors believed they were exposed to more aircraft during the visit to a national park a month previously than they actually were. A month following their visit, participants also were more annoyed, and had much lower ratings of enjoyment for their visit to the park. It would follow that if visitors are in a more negative affective state of mind, their experience in a natural environment may be significantly impaired by the noise produced by helicopter overflights both at the time of their visit and up to at least a month into the future and possibly longer.

It would be interesting in future research endeavors to focus more specifically on recreational motives and the impacts of helicopter and other aircraft noise on the attainment of the benefits brought about when immersed in a natural environment. While there is some evidence regarding differences between mountaineers and car campers with regard to their annoyance levels caused by a variety of noises (Kariel, 1990), a field study specifically targeting different recreational users would certainly add to the literature and address the multiple use mandates of many federal and state land managing agencies. For example, recently in Grand Canyon, Arizona, complaints and lawsuits have been filed against the Federal Aviation Administration from a variety of recreational users, including river rafters, backcountry hikers, and artists. Grand Canyon has a flight restriction of 1500 feet above the canyon rim in most locations throughout the park, and yet river rafters on the bottom of the canyon 5000 feet below are still able to hear and be annoyed by aircraft overflights. The question becomes the degree of annoyance experienced by different users of the environment. In the Grand Canyon a comprehensive field study should address the similarities and differences between river users, backcountry hikers, horseback riders, day hikers, helicopter and airplane tourists, artists, scenic overlookers, car campers, residents, and mountain bikers, to name a few. Other demographic characteristics such as nationality or age which vary substantially among park visitors might be differentially predictive, as might personality factors such as individualism/collectivism that could relate to social responsibility or desire for social interaction. With increases in visitation and the demands of a multiplicity of users, these types of questions are going to become ever more common in the not so distant future. Data are needed sooner rather than later in order to avoid the reactionary response that is already occurring in the more popular parks.

Even the mere presence of helicopter noise produces important reactions, independent of its source and loudness. As found in this research and in previous studies (Mace, 1997), when helicopter noise is audible (at least in the range of 40 - 80 dB(A)), many psychological reactions become much more negative. It may be that helicopter noise in natural areas is simply deemed inappropriate for the setting, and will always be rated as a negative encounter. This may be true of other noise-producing machinery, such as automobiles, snowmobiles, and jet skis. If these noise-producing items are found to yield similar results, it could be argued that as only loud noises found in nature are typically associated with fear, and on account of our history as a species being predominantly in natural surroundings, the presence of any sound that is deemed unnatural may be viewed as inappropriate and intrusive. For this reason, future research should systematically address the mere presence of helicopter and other types of noise in the just noticable range to examine this question more directly and contribute to theoretical development. Furthermore, the National Parks Overflight Act of 1997 suggests the use of quiet aircraft technology to reduce noise levels. Research, therefore, needs to systematically address this question in order to determine if this is a viable management and legislative alternative.

In a similar regard, visual intrusion of aircraft should also be addressed. If the mere presence of noise in natural surroundings has detrimental effects, then the visual presence of aircraft or other noise-producing vehicles may have a similar effect. It is always possible that alternative manipulations of source attribution, such as a flight to rescue endangered wildlife or to fight forest fires might yield less annoyance with helicopter noise. Studies examining these issue need to be completed both in the field and the laboratory.

Scenic helicopter flights are only one type of aircraft that is encountered in natural landscapes. Other aircraft include passenger jets, military in origin, or small airplane tours. Little is understood regarding the psychological reactions to these types of aircraft in national parks or wilderness areas. Furthermore, little is known about exposure to other types of mechanical noise in natural environments. Helicopters exemplify only one type of noise-producing machine that is commonly encountered in natural surroundings. Other noise-producing vehicles are currently embroiled in conflict in many national parks throughout the U.S. Debates have recently been especially heated regarding the use of jet skis and personal watercraft in protected natural areas. This is an especially interesting area to be researched, especially when considering the many research studies finding non-turbulent water environments as often the most preferred environmental type. Snowmobiles have also recently caused an uproar in Yellowstone National Park, where an estimated 60,000 snowmobiles use the park each winter (Stoddart, 1999). Disputes have erupted between snowmobilers, backcountry skiers, snowshoers, rangers, and the National Park Service itself, which illustrates the complexities of the issue and the multiple recreational motives that visitors bring to the parks. Research into these areas of noise exposure in natural environments and recreational motives is currently in its infancy.

More generally, the study of other environments, including urban versus nature settings where noise can be commonly encountered, is another important area where research is needed. Areas such as city parks, that represent islands in a sea of urbanization and are thought of as a refuge from concrete and steel, should also be studied in order to better understand the auditory environment. Urban scenes have been found to be less preferred than natural landscapes in previous research; however, sound stimuli were not included in these studies (Herzog, 1984; Ulrich, 1993). A replication of this line of research would be interesting to undertake with the addition of different sounds and noises commonly found in these types of environments.

While not the central question of concern, the multiple regression results predicting overall preference in this study show that landscape assessment includes a number of important attributes which can be affected by ambient stressors such as noise and air pollution. The use of multivariate statistical procedures, especially multiple regression, factor and cluster analyses, as well as structural equation modeling appear to be appropriate directions to undertake in future research endeavors, depending, of course, on the specific hypothesis and methodology of each researcher.

Consistent with previous research (e.g., Ross et al., 1984), impaired visibility due to haze was found to impact landscape evaluation negatively, though only for uniform haze. Interestingly, the effect size for haze was only about one-tenth that for helicopter noise, possibly because the exposure rate to haze was much less than the exposure rate to helicopter noise. Nevertheless, these results suggest that in terms of visitor enjoyment, the Park Service needs to expend at least as much effort addressing helicopter noise as it has addressing visibility impairment.

In conclusion, a lack of attention to the complexities of the natural auditory environment and its effects on human and non-human entities has resulted in an ever increasingly noisy world. While humans have primarily relied on vision as their main sensory input system and have, therefore, dedicated most of their research attention to it, the soundscape is indeed important for human and non-human species. Moreover, many non-human species rely predominantly on their auditory abilities for survival of themselves and their species. The lack of research attention to the auditory world, especially when compared to the amount of research dedicated to the visual world, represents yet another instance of anthropocentrism. With arrogant disrespect for the natural auditory environment, modern humans have spread their noise-producing items into nearly every piece and parcel of the United States and the rest of the industrialized world. Many developing nations aspire to reach the same standard of living as the industrialized world, and thus continue to spread noise ever deeper into the remaining natural areas of their nations. Noise development comes with a price tag, however, as researchers in areas such as wildlife biology, medicine, physiology, and psychology, are beginning to realize. Exposure to noise in urban and natural environments will most likely continue to escalate in coming years, and with the lack of understanding as to the effects of noise on human and non-human life, especially in the remaining natural environments, additional research is needed sooner rather than later.

References

Abey-Wickrama, I., a'Brook, M. F., Gattoni, F. W. G., & Herridge, C. F. (1969). Mental hospital admissions and aircraft noise. Lancet, 1, 1275-1277.

Alexander, W. (1968). Some harmful effects of noise. Canadian Medical Association Journal, 99, 27-31.

Amirkhan, J. H. (1990). Applying attribution theory to the study of stress and coping. In S. Graham & V. S. Folkes (Eds.), Attribution theory: Applications to achievement, mental health, and interpersonal conflict (pp. 79-102). Hillsdale, NJ: Lawrence Erlbaum Associates.

Anderson, L. M. (1981). Land use designations affect perception of scenic beauty in forested landscapes. Forest Science, 27, 392-400.

Anderson, L. M., Mulligan, B. E., Goodman, L. S., & Regen, H. Z. (1983). Effects of sounds on preferences for outdoor settings. Environment and Behavior, 15, 539-566.

Aronson, E., Wilson, T. D., & Akert, R. M. (1999). Social Psychology, 3rd edition. New York: Longman Press.

Arthur, L. M. (1977). Predicting scenic beauty of forest environment: Some empirical tests. Forest Science, 23, 151-160.

Asleson, R., & Moore, B. (1985). Dialogue with nature. Baltimore, MD: Garamond Pridemark, Inc.

Atkinson, J. W. (1957). Motivational determinants of risk-taking behavior. Psychological Review, 64, 359-372.

Atkinson, J. W. (1964). An introduction to motivation. Princeton, NJ: Van Nostrand.

Bell, P. A., Malm, W. C., Loomis, R. J., & McGlothin, G. E. (1985). Impact of impaired visibility on visitor enjoyment on the Grand Canyon: A test of an ordered logit utility model. Environment and Behavior, 17, 459-474.

Briggs, D. J. and France, J. (1980) Landscape Evaluation: A comparative study. Journal of Environmental Management, 10, 263-275.

Bronzcraft, A. L., Ahern, K. D., McGinn, R., O'Connor, J., & Savino, B. (1998). Aircraft noise: A potential health hazard. Environment and Behavior, 30(1), 101-113.

Bronzcraft, A. L., & McCarthy, D. P. (1975). The effects of elevated train noise on reading ability. Environment and Behavior, 7, 517-522.

Brown, R. S., Williams, C. W., & Lees-Haley, P. R. (1994). The effects of hindsight bias and causal attribution on human response to environmental events. Journal of Applied Social Psychology, 24(8), 661-674.

Brown, T. C., & Daniel, T. C. (1987). Context effects in perceived environmental quality assessment. Journal of Environmental Psychology, 7, 233-250.

Brown, T. C., & Daniel, T. C. (1990). Scaling of ratings: Concepts and methods. USDA Forest Service, Research Paper RM-293, Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Brown, T. C., & Daniel, T. C., Schroeder, H. W., Brink, G. E., (1990). Analysis of ratings: A guide to RMRATE. USDA Forest Service, Gen. Tech. Rep. RM-195, Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Brush, R. O. (1979). The attractiveness of woodlands: Perceptions of forest landowners in Massachusetts. Forest Science, 25, 495-506.

Buhyoff, G. J., & Leuschner, W. A. (1978). Estimating psychological disutility from damaged forest stands. Forest Science, 827-838.

Buhyoff, G. J., & Wellman, J. D. (1978). Landscape architect's interpretation of people's landscape for visual landscape dimensions. Journal of Environmental Management, 6, 255-262.

Buhyoff, G. J., & Wellman, J. D., & Daniel, T. C. (1982). Predicting scenic quality for mountain pine beetle and western spruce budworm damaged vistas. Forest Science, 28, 827-838.

Buhyoff, G. J., Miller, P. A., Roach, J. W., Zhou, D., & Fuller, L. G. (1994) An AI Methodology for Landscape Visual Assessments. AI Applications, 8, 1 - 13.

Cameron, P., Robertson, D., & Zaks, J. (1972). Sound pollution, noise pollution, and health: Community parameters. Journal of Applied Psychology, 56, 67-74.

Campbell, J. M. (1983). Ambient stressors. Environment and Behavior, 15(3) 355-380.

Carlson, A. A. (1977). On the possibility of quantifying scenic beauty. Landscape Planning, 4, 131-172.

Clean Air Act of 1977, Public Law 95-95, (1977).

Clean Air Act Act Amendments of 1977, Public Law 165 and 169A (1977).

Clean Air Act Amendments of 1990, Public Law 101-324, (1990).

Cohen, S. A., Evans, G. W., Krantz, D., Stokols, D., & Kelly, S. (1981). Aircraft noise and children: Longitudinal and cross-sectional evidence on adaptation to noise and the effectiveness of noise abatement. Journal of Personality and Social Psychology, 40, 331-345.

Cohen, S. A., Evans, G. W., Stokols, D., & Krantz, D. (1986). Behavior, health, and environmental stress. New York: Plenum.

Cohen, S., & Weinstein, N. D. (1980). Nonauditory effects of noise on behavior and health. Journal of Social Issues, 37, 36-70.

Cohen, S., & Weinstein, N. D. (1982). Nonauditory effects of noise on behavior and health. In G. W. Evans (Ed.), Environmental Stress (pp. 45-74). Cambridge: Cambridge University Press.

Crofts, R.S. (1975). The landscape component approach to landscape evaluation. Transactions of the Institute of British Geographers, 66, 124-129.

Dailey, T., & Redman, D. (1975). Guidelines for roadless area campsite spacing to minimize impact of human-related noises. USDA Forest Service General Technical Report PNW-35.

Daniel, T. C. (1984). Visual air quality and human perception of scenic vistas in Class I National Parks. Journal of Environmental Psychology, 4, 330-344.

Daniel, T. C. (1990). Measuring the quality of the natural environment. American Psychologist, 45, 633-637.

Daniel, T. C., & Boster, R. S. (1976). Measuring landscape aesthetics: The scenic beauty estimation method. USDA Forest Service, Research Paper RM-167. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Daniel, T. C., & Vining, J. (1983). Methodological issues in the assessment of landscape quality. In I. Altman & J. F. Wohlwill (eds.), Behavior and the Natural Environment, pp. 39-84, New York: Plenum Press.

Daniel, T. C., Wheeler, L., Boster, R. S., & Best, P. (1973). Quantitative evaluation of the landscape: An application of signal detection analysis to forest management alterations. Man-Environment Systems, 3, 330-344.

Dellinger, R. W. (1979). Jet roar: Health problems take off near airports. Human Behavior, 8, 50-51.

Dellora, G. B., Martin, B. V., & Saunders, R. E. (1984). Motorised recreational vehicles: perception and recreational conflict. Environmental Report No. 17, Monash University, Graduate School of Environmental Science.

Driver, B. L., & Brown, P. J. (1978). The opportunity spectrum concept and behavioral information in outdoor recreation resource supply inventories: A rationale. In H. G. Lund, V. J. LaBau, P. F. Folliott, & D. W. Robinson (Technical Coordinators), Proceedings, Integrated Inventories of Renewable Natural Resources Workshop. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station.

Driver, B. L., Nash R., & Haas, G. (1987). Wilderness benefits: A state-of-knowledge review. In Proceedings, National Wilderness Research Conference: Issues, State of Knowledge, Future Directions. Fort Collins, CO, compiled by R. C. Lucas, USDA Forest Service General Technical Report INT-220, 294-319.

Driver, B. L., Tinsley, H. E. A., & Manfredo, M. J. (1991). The paragraphs about leisure and recreation experience preference scales: Results from two inventories designed to assess the breadth of the perceived psychological benefits of leisure. In B. L. Driver, P. J. Brown, & G. L. Peterson (eds.), The benefits of leisure, pp. 263-287. State College, PA: Venture Publishing, Inc.

Dunn, M. C. (1976). Landscape with photographs: testing the preference approach to landscape evaluation. Journal of Environmental Management, 4, 15-26.

Eiser, J. R., Podpadec, T. J., Reicher, S. D., &. Stevenage, S. V. (1998). Muddy waters and heavy metal: Time and attitudes guide judgements of pollution. Journal of Environmental Psychology, 18(2), 199-208.

Eiser, J. R., Reicher, S. D., & Podpadec, T. J. (1996). Global changes and local accidents: Consistency in attributions for environmental events. Journal of Applied Social Psychology, 25(17), 1518-1529.

Fay, T. H. (Ed.). (1991). Noise and health. New York: New York Academy of Medicine.

Feimer, N. R., Smardon, R. C., & Craik, K. H. (1981). Evaluating the effectiveness of observer-based visual resource and impact assessment methods. Landscape Research, 6, 12-16.

Fields, J. M. (1990). A quantitative summary of non-acoustical variables effects on reactions to environmental noise. In I. Busch-Vishniac (Ed.), 1990 Conference on Noise Control Engineering: Reducing the annoyance of noise. Austin: University of Texas.

Finley, B. (1999). A labor of love aims high, over 14,000 feet. Denver Post, June 20, 1999, pp. 1A, 17A.

Glass, D. C., & Singer, J. E. (1972). Urban Stress. New York: Academic Press.

Gold, B. T., & Ziegler, M. (1995). Measuring environmental/biological attribution: A fundamental dimension? Journal of Social Psychology, 134(6), 837-845.

Graham, P. (1999). Environmentalists must wait for fewer Grand Canyon flights.

Denver Post, June 13, 1999, p. 18A.

Griffiths, I. D. (1983). Community response to noise. In G. Rossi (Ed.), Proceedings of the Fourth International Congress on Noise as a Public Health Problem (Vol 2, pp3-16). Milan: Centro Ricerche e Studi Amplifon.

Harrison, R. T. (1974). Sound propagation and annoyance under forest conditions. USDA Forest Service, Equipment development and test report 7120-6, San Dimas Equipment Development Center, San Dimas, CA.

Harrison, R. T., Clark, R. N., & Stankey, G. H. (1980). Predicting impact of noise on recreationists. USDA Forest Service, San Dimas Equipment Development Center, San Dimas, CA.

Health Council of the Netherlands (1994). Noise and health. The Hague: Health Council of the Netherlands.

Heider, F. (1958). The psychology of interpersonal relations. New York: Wiley.

Henry, R. C., & Matamala, L. V. (1990). Prediction of color matches and color differences in outdoor environmnet. In C. V. Mathai (Ed.), Transactions: visibility and fine particles, Pittsburgh: Air and Waste Management Association.

Herridge, C. F., & Chir, I. (1972). Aircraft noise and mental health admission. Sound, 6, 32-36.

Herzog, T. R. (1984). A cognitive analysis of preference for field and forest environments. Landscape Research, 9, 10-16.

Herzog, T. R. (1985). A cognitive analysis of preference for waterscapes. Journal of Environmental Psychology, 5, 225-241.

Herzog, T. R. (1985). A cognitive analysis of preference for natural environments:

Mountains, canyons, deserts. Landscape, 6, 140-152.

Hetherington, J., Daniel, T. C., & Brown, T. C. (1993). Is motion more important than it sounds? The medium of presentation in environmental research. Journal of Environmental Psychology, 13, 283-291.

Horonjeff, R. D., Kimura, Y., Miller, N. P., Robert, W. E., Rossano, C. F., & Sanchez, G. (1993). Acoustic data collected at Grand Canyon, Haleakala, and Hawaii Volcanoes National Parks. National Park Service, USDI, Report No. 290940.18, Denver, CO.

Hull, R. B., & Stewart, W. P. (1995). The landscape encountered and experienced while hiking. Environment and Behavior, 27, 404-426

Jackson, R. H., Hudman, L. E., & England, J. L. (1978). Assessment of the environmental impact of high voltage power transmission lines. Journal of Environmental Management, 6, 153-170.

Kanamine, L. (1997). Rift widens over curtailed Grand Canyon air tours. USA Today, March 2, 1997, pp. 3B.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. Journal of Environmental Psychology, 15, 169-182.

Kariel, H. G. (1990). Factors affecting response to noise in outdoor recreational environments. The Canadian Geographer, 34(2), 142-149.

Kelley, H. H. (1967). Attribution theory in social psychology. In D. Levine (Ed.), Nebraska symposium on motivation (pp. 192-238). Lincoln: University of Nebraska Press.

Kroh, D. P., & Gimblett, R. H. (1992). Comparing live experience with pictures in articulating landscape preference. Landscape Research, 17, 58-69.

Kryter, K. D. (1985). The effects of noise on man (2nd ed.). New York: Academic Press.

Kryter, K. D. (1994). The handbook of hearing and the effects of noise. San Diego, CA: Academic Press.

Latimer, D. A., Hogo, H., & Daniel, T. C. (1981). The effects of atmospheric optical conditions on perceived scenic beauty. Atmospheric Environment, 15, 1865-1874.

Lebo, C. P., & Oliphant, K. P. (1968). Music as a source of acoustical trauma. Laryngoscope, 78, 1211-1218.

Lee, D. (1194, July/August). Breaking the sound barrier. National Parks, 68, 25-29.

Lewin, K. (1935). A Dynamic Theory of Personality. New York: McGraw-Hill.

Lewin, K. (1938). The Conceptual Representation and the Measurement of Psychological Forces. Durham, NC: Duke University Press.

Loomis, R. J., Kiphart, M. J., Garnard, D. B., Malm, W. C., & Molenar, J. (1984). Human perception of visual air quality. Conference on Air Pollution Effects on Parks and Wilderness Areas, (pp. 30-48). Mesa Verde National Park, CO.

Mace, B. L. (1997). Aesthetic, affective, and cognitive effects of uniform haze and helicopter noise on landscape assessments of natural environments. Masters thesis, Colorado State University, Ft. Collins, CO.

Mace, B. L., Bell, P. A., & Loomis, R. J. (1999). Aesthetic, affective, and cognitive effects of noise on natural landscape assessment. Society and Natural Resources, 12(3), 259-276.

Mace, B. L., & Loomis, R. J. (1995, April). Human visual detection of uniform haze in a scenic environment. Paper presented at the meeting of the Rocky Mountain Psychological Association, Symposium on Environmental Psychology, Boulder, CO.

Malm, W. C., Leiker, K., & Molenar, J., & Chan, T. (1980). Human perception of visual air quality. Journal of the Air Pollution Control Association, 30, 122-131.

Malm, W. C., Kelley, K., Molenar, J., & Daniel, T. C. (1981). Human perception of visual air quality (uniform haze). Atmospheric Environment, 15, 1875-1890.

Malm, W. C., Ross, D. M., Loomis, R. J., Molenar, J., & Iyer, H. (1986). An examination of the ability of various physical indicators to predict perception thresholds of pulmes as a function of their size and intensity. Paper presented at the Air Pollution Control Association International Specialty Conference, Grand Teton, WY.

McDonald, C. D., Baumgartner, R. M., & Iachan, R. (1995). National Park Service aircraft management studies. National Park Service, USDI, Report No. 94-2, Denver, CO.

Nash, R. (1982). Wilderness and the American Mind (Revised Edition). New Haven, CN: Yale University Press.

National Environmental Policy Act of 1969, U.S.C. (1969).

National Park Overflights Act, Pub. L. No. 100-91, (1987).

National Park Service Act, 39 U.S.C. (1916).

National Wilderness Preservation Act, 40 U.S.C., 573. (1964).

Passchier-Vermeer, W. (1993). Noise and health. The Hague: Health Council of the

Netherlands.

Peterson, E. A., Augenstein, J. S., Tanis, D. C., & Augenstein, A. G. (1981). Noise raises blood pressure without impairing auditory sensitivity. Science, 211, 1450-1452.

Peterson, G. L., & Brown, T. C., McCollum, D. W., Bell, P. A., Birjulin, A.A., & Clarke, A. (1994). Estimation of willingness to accept compensation for public and private goods from the chooser reference point by method of paired comparison. In R. Ready (Ed.), Benefits and costs transfer in natural resource planning. Lexington, KY: University of Kentucky.

Peterson, G. L., Driver, B. L., & Gregory, R. (Eds.) (1988). Amenity resource valuation: Integrating economics with other disciplines. State College, PA: Venture.

Pitchford, M. L., & Malm, W. C. (1996). Development and applications of a standard visual index. Atmospheric Environment, 29, 231-238.

Pitt, D. G., & Zube, E. H. (1979). The Q-sort method: Use in landscape assessment research and resource planning. Proceedings of our national landscape: A conference on applied techniques for analysis and management of the visual resource, USDA Forest Service General Technical Report PSW-35. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station.

Pocock, D. C. D. (1982). The view from the bridge: Experience and recall of landscape. Occasional Paper, 17, Department of Geography, University of Durham.

Robinson, T. (1997). Testimony of Grand Canyon Trust regarding National Park Overflights and S. 268, before the Committee on Commerce, Science, and Transportation. United States Senate.

Ross, D. M., Haas, G. E., Loomis, R. J., & Malm, W. C. (June, 1984). Visibility impairment and visitor enjoyment. Paper presented at the 77th Annual Air Pollution Control Associaltion Meeting and Exhibition, San Francisco, CA.

Ross, D. M., Malm, W. C., & Loomis, R. J. (September,1986). An examination of the relative importance of park attributes at several national parks. Paper presented at the 79th Annual Air Pollution Control Association Meeting and Exhibition, Grand Teton, Wyoming.

Rotter, J. B. (1954). Social learning and clinical psychology. Englewood Cliis, NJ: Prentice-Hall.

Rutte, C. G., Wilke, H. A., & Messick, D. M. (1988). Scarcity or abundance caused by people or the environment as determinants of behavior in the resource dilemma. Journal of Experimental Social Psychology, 23(3), 208-216.

Shafer, E. L., & Brush, R. O. (1977). How to measure preferences for photographs of natural landscapes. Landscape Planning, 4, 237-256.

Shafer, E. L., & Richards, T. A. (1974). A comparison of viewer reactions to outdoor scenes and photographs of those scenes. USDA Forest Service Research Paper No. NE-302. Upper Darby, PA.

Shafer, E. L., & Tooby, M. (1973). Landscape preferences: An international replication. Journal of Leisure Research, 5, 60-65.

Shaver, C. (1998). NPS points to possible source of visibility impairment in Grand Canyon. The Vista, Spring, 1998, 8-10.

Shuttleworth, S. (1980). The use of photographs as an environmental presentation medium in landscape studies. Journal of Environmental Management, 11, 61-76.

Stamps, A. E. (1990). Use of photographs to simulate environments: a meta-analysis. Perceptual and Motor Skills, 71, 907-913.

Staples, S. L. (1996). Human response to environmental noise. American Psychologist, 51(2), 143-150.

Stoddart, V. G. (1999). Snowmobile debate in US Parks goes national with petitions from green groups. USA Today, February 12, 1999, p. 4D.

Tabachnick, B., Fidell, S., Silvati, L., Knopf, R. C., Gramann, J., & Buchanan, T. (1994). Intermediate term effects of aircraft overlights on outdoor recreationists in twelve wildernesses. National Park Service, USDI, NPOA Report No. 91-5, Denver, CO.

Tabachnick, B., Howe, R. R., Fidell, S. (1992). Estimation of aircraft overfligt exposure in National Parks and Forest Service Wildernesses. National Park Service, USDI, Report No. 92-1, Denver, CO.

Tarrant, M. A., Haas, G. E., & Manfredo, M. J. (1995). Factors affecting visitor evaluations of aircraft overflights of wilderness. Society and Natural Resources, 8, 351-360.

Tempest, W. (Ed.). (1985). The noise handbook. London: Academic Press.

Thayer, R. L., Hodgson, R. W., Gustke, L. D., Atwood, B. G., & Holmes, J. (1976). Validation of a natural landscape preference model as a predictor of perceived landscape beauty in photographs. Journal of Leisure Research, 8, 292-299.

Thurstone, L. L. (1927). A law of comparative judgment. Psychological Review, 34, 273-286.

Ulrich, R. S. (1977). Visual landscape preference: A model and application. Man -Environment Systems, 7, 279-293.

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In I. Altman & J. Wohlwill (Eds.), Behavior and the natural environment (pp, 85-125). New York: Plenum Press.

Ulrich, R. S. (1993). Biophilia, biophobia, and natural landscapes. In S. R. Kellert & E. O. Wilson (Eds.), The biophilia hypothesis. Washington D. C., Island Press.

Ulrich, R. S., Dimberg, U., & Driver, B. L. (1991). Psychophysiological indicators of leisure benefits. In B. L. Driver, P. J. Brown, & G. L. Peterson (Eds.), Benefits of leisure. State College, PA: Venture.

Vining, J., Daniel, T. C., & Schroeder, H. W. (1984). Predicting scenic quality in forested residential landscapes. Journal of Leisure Research, 16, 124-135.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. Journal of Personality and Social Psychology, 54(6), 1-8.

Weiner, B. (1985). Spontaneous causal thinking. Psychological Bulletin, 97(1), 74.84.

Weiner, B. (1990). Searching for the roots of applied attribution theory. In S. Graham & V. S. Folkes (Eds.), Attribution theory: Applications to achievement, mental health, and interpersonal conflict (pp. 1-13). Hillsdale, NJ: Lawrence Erlbaum Associates.

Weinstein, (1982). Community noise problems: Evidence against adaptation. Journal of Environmental Psychology, 2, 87-97.

Wherrett, J. R. (1996). Visualization techniques for landscape evaluation literature review. London: MLURI, Land Use Division.

Yellowstone Act, 17, U.S.C., 32. (1872).

Zube, E. H. (1974). Cross-disciplinary and intermode agreement on the description and evaluation of landscape resources. Environment and Behavior, 6, 69-89.

Zube, E. H., Pitt, D. G., & Anderson, T. W. (1974). Perception and measurements of scenic resources in the southern Connecticut River Valley. Amherst: Institute for Man and Environment, University of Massachusetts.

Zube, E. H., Pitt, D. G., & Evans, G. W. (1983). A lifespan development study of landscape assessment. Journal of Environmental Psychology, 3, 115-128.

Appendix A

Informed Consent

COLORADO STATE UNIVERSITY
INFORMED CONSENT TO PARTICIPATE IN A RESEARCH PROJECT

TITLE OF PROJECT: Landscape assessment and valuation.

NAME OF PRINCIPAL INVESTIGATOR: Paul Bell, Ph.D.

NAME OF CO-INVESTIGATOR: Britt Mace, M.S.

CONTACT NAME AND PHONE NUMBER FOR QUESTIONS/PROBLEMS: Britt Mace, 491-7125

PURPOSE OF THE RESEARCH: Environmental psychologists are interested in the attributes of landscapes that predict overall preference and liking. The purpose of this study is to add auditory stimuli commonly found in each depicted landscape in order to ascertain if sound has any effect on ratings of natural landscapes.

PROCEDURES/METHODS TO BE USED: The study you will be participating in today examines natural environments utilizing color slides. You will be asked to rate landscapes (deserts, mountains, forests, and water features) while listening to sounds commonly encountered in the depicted environment. You will be asked to complete scale ratings of emotion, scenic beauty, annoyance, solitude, tranquility, naturalness, freedom, and preference in this study. Each landscape will be visible and audible for 30 seconds, so it is imperative that you move through the rating procedure rapidly. You will have five practice slides to familiarize you with the procedure. Following the landscape ratings you will be asked to choose between private goods, public goods, and sums of money using a computerized paired comparison program. Following completion of the paired comparison task, the study is finished. In total this study will take approximately one hour of your time and you will receive one research credit for your participation.

RISKS INHERENT IN THE PROCEDURES: There are no known risks involved in this study. However, it is not possible to identify all potential risks in an experimental procedure, but the researcher(s) have taken reasonable safeguards to minimize any known and potential, but unknown, risks.

BENEFITS: Participants will learn innovative methods of landscape assessment and valuation while providing input into the important attributes of nature dominated lands.

CONFIDENTIALITY: All responses will be kept confidential. Your responses will not be used for identification purposes in any way.

LIABILITY: The Colorado Governmental Immunity Act determines and may limit Colorado State University's legal responsibility if an injury happens because of this study. Claims against the University must be filed within 180 days of the injury.

Questions about subjects' rights may be directed to Celia S. Walker at (970) 491-1563.

PARTICIPATION: Your participation in this research is voluntary. If you decide to participate in the study, you may withdraw your consent and stop participating at any time without penalty or loss of benefits to which you are otherwise entitled.

Your signature acknowledges that you have read the information stated and willingly sign this consent form. Your signature also acknowledges that you have received, on the date signed, a copy of this document containing _1_ page.

____
Participant name (printed)

____________________________ _______________
Participant signature Date

____________________________ _______________
Investigator or co-investigator signature Date

Page 1 of 1 Participant initials _______ Date _______

Appendix B

Positive and Negative Affect Scale

This scale consists of a number of words that describe different feelings and emotions. Read each item, and then mark the appropriate answer in the space next to that word. Indicate to what extent you feel this way right now, that is, at the present moment. Use the following scale to record your answers.

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

interested	___	irritable	___
distressed	___	alert	___
excited	___	ashamed	___
upset	___	inspired	___
strong	___	nervous	___
guilty	___	determined	___
scared	___	attentive	___
hostile	___	jittery	___
enthusiastic	___	active	___
proud	___	afraid	___

Appendix C

Instruction Set for the Control Condition

Landscape Evaluation Instructions

We are interested in the attributes of pristine environments that contribute to our evaluations of these environments. During the next few minutes, you will be shown slides depicting a variety of natural scenes of national parks located throughout the southwestern United States. During the time when the slides are shown, you will also hear sounds that occur in these types of environments. These are sounds you would typically encounter if you were a visitor to the depicted environment. You will be asked to evaluate these landscapes on a variety of dimensions, including scenic beauty, naturalness, solitude, tranquility, freedom, annoyance, and overall preference. When rating a given environment, it is important to consider the entire range of stimuli. Therefore, you should focus your attention on the visual and auditory components that are present in each depicted environment. As you view the landscapes and listen to the sounds presented, please use the slide and sound as an indication of what the depicted area is like, and rate the area as if you were a visitor to the national park. In other words, imagine you are actually present in the depicted landscape when making your ratings. If you have any questions, please feel free to express them before the experiment begins. PLEASE REMEMBER TO ENVISION YOURSELF AS BEING PRESENT IN THE ENVIRONMENT WHEN MAKING YOUR RATINGS.

c

Appendix D

Instruction Set for the Tourist Flight Condition

Landscape Evaluation Instructions

We are interested in the attributes of pristine environments that contribute to our evaluations of these settings. During the next few minutes, you will be shown slides depicting a variety of natural scenes of national parks located throughout the Southwestern United States. During the time when the slides are shown, you will also hear sounds that occur in these types of environments. These are sounds you would typically encounter if you were a visitor to the depicted environment. In fact, you will even hear the sounds of helicopters, as tourists fly around the National Parks aboard commercially operated helicopter trips. You will be asked to evaluate these environments on a variety of dimensions, including scenic beauty, naturalness, solitude, tranquility, freedom, annoyance, and overall preference. When rating a given environment, it is important to consider the entire range of stimuli. Therefore, you should focus your attention on the visual and auditory components that are present in each depicted environment. As you view the landscapes and listen to the sounds presented, please use the slide and sound as an indication of what the depicted area is like, and rate the area as if you were a visitor to the national park. In other words, imagine you are actually present in the depicted landscape when making your ratings. If you have any questions, please feel free to express them before the experiment begins. PLEASE REMEMBER TO ENVISION YOURSELF AS BEING PRESENT IN THE ENVIRONMENT WHEN MAKING YOUR RATINGS.

t

Appendix E

Instruction Set for the Rescue Operation Condition

Landscape Evaluation Instructions

We are interested in the attributes of pristine environments that contribute to our evaluations of these settings. During the next few minutes, you will be shown slides depicting a variety of natural scenes of national parks located throughout the southwestern United States. During the time when the slides are shown, you will also hear sounds that occur in these types of environments. These are sounds you would typically encounter if you were a visitor to the depicted environment. In fact, you will even hear the sounds of helicopters, as the National Park Service rescues visitors from the backcountry. You will be asked to evaluate these environments on a variety of dimensions, including scenic beauty, naturalness, solitude, tranquility, freedom, annoyance, and overall preference. When rating a given environment, it is important to consider the entire range of stimuli. Therefore, you should focus your attention on the visual and auditory components that are present in each depicted environment. As you view the landscapes and listen to the sounds presented, please use the slide and sound as an indication of what the depicted area is like, and rate the area as if you were a visitor to the national park. In other words, imagine you are actually present in the depicted landscape when making your ratings. If you have any questions, please feel free to express them before the experiment begins. PLEASE REMEMBER TO ENVISION YOURSELF AS BEING PRESENT IN THE ENVIRONMENT WHEN MAKING YOUR RATINGS.

r

Appendix F

Instruction Set for the Trail Maintenance Condition

Landscape Evaluation Instructions

We are interested in the attributes of natural environments that contribute to our evaluation of these settings. During the next few minutes, you will be shown slides depicting a variety of natural scenes of national parks located throughout the southwestern United States. During the time when the slides are shown, you will also hear sounds that occur in these types of environments. These are sounds you would typically encounter if you were a visitor to the depicted environment. In fact, you will even hear the sounds of helicopters, as the National Park Service flies into the backcountry to make improvements to hiking trails. You will be asked to evaluate these environments on a variety of dimensions, including scenic beauty, naturalness, solitude, tranquility, freedom, annoyance, and overall preference. When rating a given environment, it is important to consider the entire range of stimuli. Therefore, you should focus your attention on the visual and auditory components that are present in each depicted environment. As you view the landscapes and listen to the sounds presented, please use the slide and sound as an indication of what the depicted area is like, and rate the area as if you were a visitor to the national park. In other words, imagine you are actually present in the depicted landscape when making your ratings. If you have any questions, please feel free to express them before the experiment begins. PLEASE REMEMBER TO ENVISION YOURSELF AS BEING PRESENT IN THE ENVIRONMENT WHEN MAKING YOUR RATINGS.

bc

Appendix G

Landscape Evaluation Scales

Slide #____

Scenic Beauty

______:______:______:______:______:______:______:______:______:______
very low very high

Naturalness

______:______:______:______:______:______:______:______:______:______
unnatural very natural

Freedom

______:______:______:______:______:______:______:______:______:______
very low very high

Annoyance

______:______:______:______:______:______:______:______:______:______
very low very high

Solitude

______:______:______:______:______:______:______:______:______:______
very low very high

Tranquility

______:______:______:______:______:______:______:______:______:______
very low very high

Preference

______:______:______:______:______:______:______:______:______:______:
very little a great deal

Appendix H

Demographic and Attitude Questionnaire

Demographic and Attitude Questions

1 = strongly agree to 7 = strongly disagree

I often notice airplanes and helicopters flying overhead when I visit national parks.

There should be no restrictions where commercial helicopters can fly over national parks.

The opportunity to experience natural quiet and the sounds of nature are more important than the benefits gained on a air tour.

People visiting a national park on the ground should have an experience free from helicopter noise.

The national park service should be allowed to fly in materials for trail improvements using helicopters.

The noise produced by helicopters used by the park service for the removal of an injured backcountry visitor does not bother me.

Visitors who need to be rescued by helicopter from the backcountry should have to pay for their rescue.

What is your gender? (F for female, M for male)

What is your age?

How many years of education have you completed?

What is the population of your hometown?

How many visits have you made to a national park during the past year?

Have you ever taken a helicopter tour of a national park? If yes, how many helicopter tours have you taken, and in which national park(s)?

How many environmental groups do you currently belong to?

Appendix I

Noise Sensitivity Scale

Noise Sensitivity Scale

In the space by each item, put the number from the scale below that best reflects your answer.

1	2	3	4	5	6
Agree Strongly	Agree	Agree Slightly	Disagree Slightly	Disagree	Disagree Strongly

_____ 1. I wouldn't mind living on a noisy street if the apartment I had was nice.
_____ 2. I am more aware of noise than I used to be.
_____ 3. No one should mind much if someone turns up his stereo full blast once in a while.
_____ 4. At movies, whispering and crinkling candy wrappers disturb me.
_____ 5. I am easily awakened by noise.
_____ 6. If it's noisy where I'm studying, I try to close the door or window or move someplace else.
_____ 7. I get annoyed when my neighbors are noisy.
_____ 8. I get used to most noises without much difficulty.
_____ 9. How much would it matter to you if an apartment you were interested in renting was located across from a fire station.
_____ 10. Sometimes noises get on my nerves and get me irritated.
_____ 11. Even music I normally like will bother me if I'm trying to concentrate.
_____ 12. It wouldn't bother me to hear the sounds of everyday living from neighbors(footsteps, running water, etc.).
_____ 13. When I want to be alone, it disturbs me to hear outside noises.
_____ 14. I'm good at concentrating no matter what is going on around me.
_____ 15. In a library, I don't mind if people carry on a conversation if they do it quietly.
_____ 16. There are often times when I want complete silence.
_____ 17. Motorcycles ought to be required to have bigger mufflers.
_____ 18. I find it hard to relax in a place that's noisy.
_____ 19. I get mad at people who make noise that keeps me from falling asleep or getting work done.
_____ 20. I wouldn't mind living in an apartment with thin walls.
_____ 21. I am sensitive to noise.

Appendix J

Debriefing

Debriefing

Our study on the landscape assessment of scenic environments is designed to assess the impact of ambient environmental stressors such as air pollution and noise. Previous research has focused extensively on the effects of these ambient environmental stressors within the urban environment, yet, in comparison, very little research has been undertaken to examine their effects in natural environments. As urban areas throughout this country and the world continue to expand, the by–products of industrial civilization have begun to encroach on the remaining natural areas. Therefore, it is exceedingly important to study the effects these stressors have on human behavior in these environments. This point becomes especially poignant when considering that wilderness has come to be regarded as an escape from the restrictions of urban life. In recent years, air pollution in the Southwestern quadrant of the United States has dramatically increased. In addition, the popularity of the region has also increased, and helicopter air tours have responded accordingly, expanding with an exponential frequency. Today in the Grand Canyon there are 42 independent helicopter tour operators. Consequently, exposure to noise produced by these helicopters is highly probable when visiting the area. In fact, research has indicated that a visitor may be exposed to as many as 43 separate aircraft noise events within a 20–minute span. Furthermore, with increases in visitation over recent years, the national park service has increased its own helicopter flights for such activities as trail maintenance and improvement as well as backcountry rescue operations. With these points in mind it is easy to recognize why aircraft overflights, air pollution, and visitor management have become very popular topics in the natural areas of the United States. The landscape assessments you have completed today will provide a better understanding of how these stressors may impact the human experience within the natural landscapes of the United States and the world. The results you have provided can be utilized by those involved in federal land management and enforcement of such laws as the National Wilderness Preservation Act, the National Park Overflights Act, and the National Environmental Policy Act. Your participation is critical to the development of land–use policies and an understanding of the affective and aesthetic components of a natural landscape experience. Thank you. If you have any questions, comments, or concerns, please contact Britt Mace at 491-7125 or Paul Bell at 491–7215.