IMPACTS OF NATURAL ZOO DESIGN ON THE ACTIVE MENTAL STATE OF VISITORS AND THEIR PERCEPTIONS OF ZOOS

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ABSTRACT

Zoological institutions have always struggled to gather support for their conservation efforts due to the various ethical dilemmas perceived by the public (Milstein, 2009). Present-day zoos must carefully balance their funding to ensure enough is allocated to keep visitors excited and engaged, while also conducting conservation work and caring for often costly animals (Carr & Cohen, 2011). Many people do not realize that their support through visits to zoological parks is crucial for keeping zoos open, allowing them to care for their animals and contribute to conservation efforts and species survival plans worldwide. Research shows that visitors with a previous positive experience at a zoo are more likely to support conservation efforts than those who had a negative experience or did not visit a zoo at all (Godinez & Fernandez, 2019). This study aims to answer whether exhibit design elements, such as size, vegetation density, and material types, directly influence visitor emotions, perceptions of the zoo, and perceptions of animal welfare. A total of 187 surveys were collected from visitors at three AZA-accredited zoos in Michigan, providing insight into the relationship between enclosure design characteristics and visitor satisfaction and emotions. The main findings reveal that animal affinity is a strong factor in visitor experience, but that certain design aspects, like exhibit scale, vegetation density, and material choice also have strong impacts on visitor emotions and perceptions of zoo design. Future research should explore broader geographic contexts, diverse exhibit types, and the long-term impact of educational interventions on visitor perceptions. Understanding these factors can aid zoos in refining their strategies to enhance both visitor experience and conservation messaging.

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CHAPTER 1. INTRODUCTION

Many outsiders believe that current zoos are simply menageries, purely designed for the human enjoyment of animals on display, much like zoological parks that were originally created by the wealthy and royal (Carr & Cohen, 2011). While some unaccredited parks may still have less-than-ideal circumstances for their inhabitants, many zoos and wildlife parks across the world are a part of the Association of Zoos and Aquariums (AZA) or other similar accrediting groups including the World Association of Zoos and Aquariums (WAZA) and the European Association of Zoos and Aquaria (EAZA). Members of these associations strive for the best possible care for their animals while also pursuing various conservation efforts (Association of Zoos & Aquariums, 2023). According to the AZA, accredited institutions must follow specific standards of thirteen categories, including animal welfare, veterinary care, conservation, education, guest services, and master planning. The topic of animal welfare has only become of interest relatively recently, as more is gradually understood by researchers about the mental capacity of other animals (Broom, 1991).

After re-evaluating the animals' need for environmental enrichment, zoos began to transition exhibit designs from the old cage and bear pit-style enclosures to more naturalistic representations of different ecosystems (Bitgood & Patterson, 1987). The concept of *natural zoo design* was born through innovative designers like Carl Hagenbeck in the 19th century and *immersion habitats* were created by Jon Coe, along with Grant Jones, across the United States in the early 1970s (Ponti, 2017). This new way of designing habitats considered the animals' natural environment rather than just displaying the most valuable animals in basic, easy-to-maintain enclosures (Clayton et al., 2008). By housing animals in more natural habitats, they can exhibit more species-specific behaviors, which in turn helps the emotional connection visitors may make with individual animals or species, and encourage further contributions to conservation (Clayton et al., 2017).

My study aims to analyze what factors in natural zoo design contribute to a positive experience for visitors, in turn encouraging their support or participation in zoos' conservation efforts. The use of accurate terrain, vegetation, and water elements, as well as proper signage, lend to great natural zoo design, which effectively engages zoo visitors and actively educates them on biodiversity and conservation (Clayton et al., 2008). Zoos depend on the support of visitors to be able to contribute monetarily to conservation efforts, so understanding what aids in fostering visitor support is extremely important (Godinez & Fernandez, 2019). By studying both current natural zoo design and how visitors interact with exhibits, the relationship between the two can possibly be identified. Using past research on the impacts of general zoo visits on people, it can be assumed that positive experiences in zoos lead to repeated interaction with them and increased support for biodiversity and conservation (Clayton et al., 2017).

Through quantitative data, my goal is to study the possible relationships between exhibit design and visitor experience, while also considering perceptions of animal welfare. I chose three zoos across Michigan to be included in the study based on size and financial resources. At each zoo, I chose three separate exhibits that fall into different categories of design features. All nine exhibits featured diurnal or crepuscular mammals to limit any drastic animal activity or charisma factors that could impact visitors' opinions. I collected short online surveys from visitors near each of the selected exhibits during the summer months of 2024. These surveys can give insight into what visitors look for in exhibits, with questions about different aspects of natural design, as well as their perceptions of the animals and overall experience at the zoo. The questionnaire responses were then analyzed using correlation, cluster analysis, and ANOVA tests to identify common patterns among visitors.

I hypothesized that a positive correlation would be seen between more naturalistic design (larger, with denser vegetation and more invisible barriers) and visitors' impressions of the zoo. The observation data may show that exhibits with more immersive and natural elements, as well as animals that actively engage with their environment, will encourage visitors to stay longer, thereby increasing the overall time they spend at the zoo. As previously found, the more time someone spends at a zoo, the more likely they are to support the institution, whether monetarily or just morally (Godinez & Fernandez, 2019). Both design and animal activity are equally as important in maintaining or improving the conservation efforts of zoos. My questionnaires showed which elements are most effective at keeping visitors excited and engaged, as well as provided ideas for future designs that have not yet been focused on. The use of public engagement, in this case, could be extremely insightful into what is lacking in modern zoo design in the public eye.

From my study, there were significant results regarding the relationships among the most important factors: zoo design and zoo visitor experiences. Future zoo design can be bolstered by data that confirms what other research has previously discussed. Through the use of natural zoo design, future zoo projects can be effectively engaging for visitors, thereby encouraging visitors to make their own contributions to conservation efforts (Clayton et al., 2017). Further research could be pursued that studies broader geographical contexts and varying exhibit species, as well as the direct impacts of natural design on animal welfare and activity, as these may also play an important role in visitor engagement. If an animal seems out of place to a visitor, they may be more likely to view the zoo as simply a tool for human enjoyment; but if an animal seems to happily belong in the environment it has been placed, the visitor may be far more likely to support the zoo's mission.

CHAPTER 2. LITERATURE REVIEW

Zoos have long served as institutions of entertainment, education, and conservation, yet their design and function continue to evolve alongside changing societal values and scientific advancements. While past research has extensively explored animal welfare, species-specific husbandry, and visitor-animal interactions, there remains a significant gap in understanding how zoo exhibit design influences visitor perceptions and overall experience. This chapter examines key areas of literature related to zoo history, exhibit design principles, visitor engagement, and the effects of nature immersion, providing the foundation for my study's investigation into how different demographic groups perceive enclosure design and its impact on their zoo experience.

The chapter begins by following the historical evolution of zoos, highlighting the shift from exploitive menageries to modern conservation-focused institutions. It then explores naturalistic zoo design, focusing on how enclosure aesthetics and spatial planning contribute to both animal welfare and visitor engagement. This is followed by an analysis of AZA guidelines for species-specific exhibit standards, providing a framework for evaluating modern zoo practices. Given that visitor experience extends beyond just observing animals, this review also considers how human-animal interactions and broader visitor perceptions shape attitudes toward zoos. Existing research on public engagement with wildlife, conservation messaging, and perceived animal welfare will be examined to understand the factors influencing zoo credibility and visitor satisfaction. Additionally, this chapter reviews the literature on nature immersion and its psychological benefits, exploring how exposure to naturalistic environments in zoos may enhance visitor well-being and reinforce conservation awareness.

By synthesizing these areas of research, this chapter establishes the groundwork for exploring how enclosure design affects visitor perception across diverse demographic groups. Identifying gaps in the existing literature will clarify the need for further investigation into the role of exhibit design in shaping public attitudes toward zoos and conservation efforts.

2.1 History of Zoos

The concept of a zoo has evolved significantly throughout history. Jamieson in *Against Zoos* (2002) examines this transformation, particularly the role of zoos as forms of entertainment. Initially, animal collections, or *menageries*, were built by the wealthy and royal as symbols of their position and for entertainment purposes (Jamieson, 2002). Grand estates may have contained especially exotic collections, most often in private garden settings, for viewing or simply just to have the ability to claim them as property. Beyond private ownership, animals were also central to public entertainment. For example, the Romans were notorious for their use of dangerous animals, such as elephants, tigers, and crocodiles, in 'games' where the animals almost always ended up brutally slaughtered for an audience (Jamieson, 2002).

By the eighteenth century, the desire to have access to these wild animals started to shift from just the elite to the general public. The first *public* animal collections emerged in various European cities, eventually leading to the development of thousands of zoos across the whole world (Jamieson, 2002). Initially, these facilities were still primarily viewed as entertainment venues with animals confined in cages or concrete enclosures for ease of viewing and maintenance. However, the eighteenth and nineteenth centuries, often referred to as the Age of Enlightenment, and preceded by the Age of Science, brought a growing emphasis on understanding the natural world. A significant milestone in this transition was the establishment of the London Zoo in 1828 by the Zoological Society of London, opened to the public in 1847, which played a pivotal role in shifting zoos from entertainment-driven attractions to institutions focused on public education and worldwide conservation. Notably, the London Zoo is credited with coining the term "*zoo*" (London Zoo, 2025). Following this model, many other countries developed their own zoos to foster public engagement with animals and promote a deeper understanding of the natural world.

Despite these advancements, (Jamieson, 2002) argued that modern zoos cause more harm than good, subjecting animals to unjust suffering for the sake of human entertainment. He highlighted several cases in recent history where animals in American zoos were found to be mistreated or neglected, often housed in inadequate environments due to a lack of understanding of their behavioral needs. The concern for designing enclosures with specific animal behaviors in mind has been growing since the early twentieth century, with pioneers in animal welfare, such as Mary Akeley in 1936, advocating for the idea that animals placed outside their natural environment may exhibit unnatural behaviors, thus misrepresenting their true nature (Coe, 1985). Over the past fifty years, the awareness of animal welfare has increased dramatically, becoming a central focus of modern zoos and aquariums. Ensuring high standards of animal care is now essential to the success of zoological institutions and their ability to contribute meaningfully to global conservation efforts.

This increasing emphasis on animal welfare led to institutional reforms within the zoo industry. In 1971, the Association of Zoos and Aquariums (AZA) established a committee to develop professional standards for zoological institutions (AZA, 2023). The first zoo received AZA accreditation in 1974, and by 1985, the organization had shifted its primary focus to stricter regulations aimed at improving animal husbandry and care (AZA, 2023). Today, the AZA regulations are considered to be the established national standard by most zoological institutions, related facilities, and agencies like OSHA and the USDA (AZA, 2023). Over 250 institutions are accredited, as of 2024, across the entire United States, as well as in many international countries, including Spain, South Korea, and the UAE (AZA, 2024). Species Survival Plans (SSPs) and Saving Animals from Extinction (SAFE) programming are created to help zoos work together to diversify the gene pools in zoo animal populations and optimize species management practices, specifically with threatened or endangered species. Despite being accredited by the AZA, many zoos struggle to transition away from the menagerie model of exhibit design, due to their age and historic infrastructure or budget restrictions that prevent full renovations in short periods. As a result, state-of-the-art enclosures often exist alongside outdated exhibits that reflect past approaches to housing animals.

The idea of an animal collection or zoological park has drastically changed over the last few centuries, from private, exploitive ownership of animals, to an organized approach that considers multiple facets, including conservation, education, and entertainment. However, there are continual advancements to the scientific basis for zoological park design that modern zoos must consider.

2.2 Natural Exhibit Design

The modern zoo must accomplish much more than amassing an impressive collection of exotic animals. There are many facets of a successful institution, including successful business models, meaningful conservation, effective education outreach, and considerations for animal welfare and visitor satisfaction. The AZA provides a comprehensive guide to the many pillars of a 'good' zoo (AZA, 2025). There are detailed descriptions of the minimum expectations of an accredited institution, as well as additional steps that can be taken beyond the increasingly shifting requirements to reach longstanding zoo excellence. The AZA Accreditation Standards address their expectations, which are categorized into 13 aspects of zoo operations, each updated and refined annually to reflect advances in knowledge or technology. The categories include animal care, veterinary care, conservation, education, scientific advancement, finances, safety, and other operations (AZA, 2025).

Coe's work in naturalistic zoo design has significantly influenced modern exhibit development. Much like his predecessor and the *father of natural zoo design*, Carl Hagenbeck, Coe has spent over fifty years working to create natural zoos that promote good animal welfare. In *Design and Perception: Making the Zoo Experience Real* (1985), Coe explores how behavioral principles can shape immersive enclosures, drawing inspiration from Hagenbeck's pioneering use of spatial illusions to create the appearance of shared environments between animals and visitors while ensuring safety (Coe, 1985).

One of Coe's most notable projects was the redesign of the gorilla enclosure at Woodland Park Zoo in 1979, which marked a shift from traditional, restrictive enclosures to more naturalistic habitats (Ponti, 2017). At the time, gorillas were often confined to concrete spaces with limited environmental stimulation for ease of cleaning and to prevent unwanted or destructive behaviors. Coe transformed a former bear grotto into a West African rainforest-inspired exhibit, incorporating a hidden moat and a forty-foot maple tree to encourage natural climbing and surveying behaviors. This design remains a model for balancing animal welfare with visitor engagement (Ponti, 2017). Visitors can feel like they are physically inside the gorillas' environment, fostering positive interactions and resulting emotions about the animals and the zoo.

While Coe's work advanced naturalistic enclosures, perspectives on good zoo design vary widely. Boyle (2017) highlights this debate, noting that animal rights organizations such as PETA argue that no captive setting can fully meet an animal's needs. On the other end of the spectrum, unaccredited facilities often prioritize cost efficiency over welfare, offering enclosures that fail to support species-specific behaviors. Accredited institutions, such as those under the AZA, strive for a balance, recognizing that enclosure quality significantly impacts animal well-being and must continuously evolve to meet higher welfare standards (Boyle, 2017). A key principle in modern exhibit design is providing animals with choice, mirroring aspects of their natural environment. Boyle (2017) found that effective enclosures allow animals to move freely between indoor and outdoor spaces, seek shade or sunlight, and regulate their visibility. Additionally, well-designed habitats must accommodate keeper safety and accessibility, ensuring efficient care while minimizing stress for both staff and animals.

Beyond enrichment, safety considerations are crucial in exhibit design, particularly concerning zoonotic risks and species-specific behaviors. The UK's Standards of Modern Zoo Practice (DEFRA, 2012) classifies animals into three risk categories to guide habitat design and safety protocols. Category 1 includes high-risk species that pose a serious threat due to physical danger or disease transmission, such as great apes, bears, wolves, and venomous reptiles. All the species chosen for this study are considered Category 1 animals. Category 2 consists of moderate-risk species that may cause injury or illness but are not typically life-threatening, including lemurs, opossums, and most turtle species. Category 3 encompasses low-risk species not listed in the previous categories but still requiring safety assessments. These classifications help zoos implement appropriate barriers, handling procedures, and protective measures to ensure the safety of both animals and the public.

2.3 AZA Animal Care Guidelines

Various manuals and husbandry guidelines have been created through the AZA, previously named the AZAA (American Zoo and Aquarium Association), in order to streamline expectations for the proper care of captive animals. They are usually developed by taxon advisory groups (TAGs), or committees consisting of professionals in various applicable zoo-related fields. The manuals are based on scientific data and information about the natural history and management strategies of various taxa (AZA, 2023).

In order to create an effective environment for a specific individual or group of animals, one must analyze the basic spatial and environmental requirements of the species being housed. In this study, 6 different species are of interest, all belonging to *Category 1* on the "Standards of Modern Zoo Practice" list. The following analysis examines exhibit design guidelines established by the Association of Zoos and Aquariums (AZA) for these species. *Table 1* summarizes the information.

2.3.1 North American River Otter (*Lontra canadensis*)

The AZA Otter Care Manual provides an in-depth description of what different otter species need when kept in captivity. For North American river otters (*l. canadensis*), it is recommended they have at least 150m² for two individuals, with an additional 35m² for every additional individual. Regarding the design of their space, they require a semi-aquatic environment with the land portion being composed of a variety of "soft loose natural substrates" that allow the otters to engage in natural behaviors like digging, foraging, or grooming. There should also be added physical and visual complexity through various live plants and log structures that provide shelter and more active opportunities (AZA Small Carnivore TAG, 2009).

2.3.2 Canadian Lynx (*Lynx canadensis*)

According to the AZA Small Felid Guidelines, which can be referenced for Canadian lynx care, only 20m³ is required for one individual, with an extra 4m² of floor space for each additional animal. Note that for this species, which is known for climbing, the design of the vertical space of the enclosure is just as important as the horizontal plane. It is recommended that cats have access to at least 75% of the exhibit's vertical space and that they tend to prefer perches in higher spots that allow better surveillance of the environment. Additionally, there should be materials, like rotting logs, for the Lynx to sharpen their claws and there should be areas allocated for dens that the cats can utilize for shelter and safety (Mellen, J.D., 1997).

2.3.3 Grey Wolf (*Canis lupus*)

The AZA Large Canid Manual provides guidance in the care of grey wolves, which reportedly require at least 465m² for two individuals, plus 93m² per additional animal. These guidelines also specify the need for a secondary holding space of at least 38m² for two individuals. As far as exhibit design goes, canids thrive with flatter, open terrain composed of natural materials like grass, dirt, or sand. A variety of trees and shrubs can provide opportunities for natural behaviors like hiding or scent marking. It is also noted that water features are encouraged to introduce a source of constant change and visual interest for both inhabitants and visitors (AZA Canid TAG, 2012).

2.3.4 Grevy's Zebra (*Equus grevyi*)

For Grevy's zebra, the AZA Equid Guidelines suffice for husbandry information. 186m² are required per individual in a breeding or bachelor herd, with a secondary indoor holding space of at least 6.5m² per individual. Outdoors, this gregarious species requires a wide-open space that allows individuals to roam and to limit stereotypic behaviors. A variety of grasses and trees provide the zebras with visual barriers and shade, but it is noted that the vegetation should be protected from grazing and not relied on for the animals' diet (Fischer & Shurter, 2001).

2.3.5 Mountain Bongo (*Tragelaphus eurycerus isaaci*)

For mountain bongos, which are a very rare, near-extinct species in the wild, there is not much specific information available for their care. However, similarly sized antelope, like Wildebeest, have guidelines in the AZAA (AZA) Antelope Husbandry Manual. It is recommended to provide these large ungulates with at least 74m² for two individuals, with 18.5m² per additional animal. They also need a secondary holding space of at least 6.5m² per individual. Similarly to zebras, these species should have different trees and grasses to provide environmental variety and shade opportunities (AZAA Antelope TAG, 2001).

2.3.6 Elk (*Cervus canadensis*)

It is noted that there are no reputable sources available for keeping Elk in captivity, so for these animals, one can refer to the AZA Equid Guidelines (Fischer & Shurter, 2001) and AZAA (AZA) Antelope Husbandry Manual (AZAA Antelope TAG, 2001) for guidance, as ecologically similar species. Special consideration should be made for bull males with large antlers.

Species	Exhibit Size	Spatial Considerations	Source
North American River Otter (*Lontra canadensis*)	150m² for 2 individuals + 35m² per additional individual	Semi-aquatic environment, variety of loose substrates, & complexity through use of logs and vegetation	AZA Otter Care Manual (AZA Small Carnivore TAG, 2009)
Canadian Lynx (*Lynx canadensis*)	20m³ for 1 individual + 4m² floor space per additional individual	Cats need access to >75% of their vertical space, include materials for claw-sharpening, and provide various shelters	AZA Small Felid Guidelines (Mellen, J.D., 1997)
Grey Wolf (*Canis lupus*)	465m² for 2 individuals + 93m² per additional individual	Open terrain, variety of trees and shrubs, & water features encouraged	AZA Large Canid Manual (AZA Canid TAG, 2012)
Grevy's Zebra (*Equus grevyi*)	186m² per individual + 6.5m² secondary indoor holding per individual	Open terrain, variety of grasses and shade trees	AZA Equid Guidelines (Fischer, M., & Shurter, S., 2001)
Mountain Bongo (*Tragelaphus eurycerus isaaci*)	74m² for 2 individuals + 18.5m² per additional individual	Open terrain, variety of grasses and shade trees	AZAA Antelope Husbandry Manual (AZAA Antelope TAG, 2001)
Elk (*Cervus canadensis*)	186m² per individual + 6.5m² secondary indoor holding per individual	Open terrain, variety of grasses and shade trees; Wide doorways for males with large seasonal antlers	AZA Equid Guidelines (Fischer, M., & Shurter, S., 2001)

Table 1. Summary of exhibit recommendations for study species

2.4 Zoo Visitors and Animals

The prevailing focus within zoo research often leans heavily towards the implications of perceived animal welfare rather than the effects of natural zoo design on visitors. Luebke et al. (2016) assessed visitor responses to popular large mammals such as giraffes and lions. This research also examined the effects of animal interaction on visitor affective state and further 'meaning-making' regarding conservation issues, which is important for the long-term positive effects of public perception on zoos. However, while the findings contribute to the discussion on human-animal interactions, the study provides limited analysis of the role of naturalistic exhibit elements. Additionally, the study also only surveyed three zoos suggesting that it would be beneficial to repeat the survey with a larger sample size, especially if expanded internationally.

Compounding this, Howell et al. (2019) measured the relationship between zoo visitors' connectedness to their favorite animals and the visitors' concern for wildlife conservation. It was found that many participants chose large mammals as their 'favorite,' with 87.95% choosing mammals, and 86.3% of those people choosing mammals larger than a meerkat or red panda. This evidence will contribute to the decision in this thesis to use only 'large mammals,' as seen in *Section 3.1*. Like Luebke et al.'s (2016) study, Howell et al. (2019) found that visitor connectedness to the animals was significantly correlated with visitor willingness to help conservation through donations or other actions.

Further supporting this trend, Hacker & Miller (2016) found that visitors with the opportunity to witness active elephant behaviors up close led to a greater change in conservation intent. However, while the study acknowledged the role of exhibit space, it did not directly assess how exhibit design influenced visitor perception, a common limitation among zoo-related research. More recent studies have examined how visitor attitudes shift based on species type. Ogle and Devlin (2022) explored the indirect effects of keeping reptiles and amphibians, taxa often viewed as undesirable by the public. They analyzed how animal "like-ability" and perceived welfare influenced visitor engagement, including the likelihood of return visits and institutional support (Ogle & Devlin, 2022). From 616 responses, they found that individuals with greater species knowledge or higher education levels were more likely to perceive better animal welfare. However, the study acknowledged several limitations, including demographic discrepancies—71% of respondents were females over 18, differing significantly from the AZA's visitor demographic, where 54% are female and 57% are children under 12 (AZA, 2023). Additionally, limiting the study to Florida-based zoos may have skewed results, as herpetofauna are more common in the region compared to other geographical locations.

Animal activity itself also plays a significant role in influencing visitor perceptions. For example, Miller (2011) found that those who viewed pacing tigers had significantly lower scores for animal care/welfare and zoo support than those who viewed resting tigers. This supports the idea that reducing stereotypic behaviors in captive animals should be a goal for zoos in order to increase visitor satisfaction. Building on this idea, Lacinak (2023) investigated how zoo visitors perceive animal welfare states based on live caretaker-animal interactions, specifically during training sessions. It was found that positive relationships between caregivers and zoo residents significantly impacted participants' perceptions of animal welfare states. Participants consistently identified 'positive' actions like the animals approaching the caregivers when spoken to or accepting physical interactions, such as a pat on the head or scratch on the neck. These findings demonstrate that visitors may have more positive perceptions of animal welfare when the animals are more active or interactive with their environment or caregivers.

2.5 Visitor Perception of Zoos

Visitor perceptions of zoos extend beyond impressions of individual animals' welfare to their overall view of zoological institutions. Carr & Cohen (2011) analyzed the websites of 54 different zoos across the world to see what sort of messages were conveyed to viewers about the zoos' missions. They recommended that zoos emphasize conservation over entertainment to strengthen their credibility. While this study provides insights into how zoos present themselves online, it does not address the impact of in-person zoo visits, where visitors' impressions are shaped by direct experiences with animals and their environments.

Woods (2002) found that positive experiences were often associated with interactions with or learning about wildlife, while negative experiences resulted from poor animal management, inadequate facilities, or threatening animal behavior. These results suggest that while animal interactions play a key role in shaping visitor perceptions, the quality of zoo infrastructure and exhibit design is equally crucial. Clayton et al. (2008) further explored this relationship by studying the impact of zoo visits on conservation attitudes and emotional engagement. Their study found that zoo animals serve as conversation facilitators, helping to foster positive attitudes toward conservation. However, similar to Woods' findings, this research primarily focused on human-animal interactions, overlooking the role that naturalistic exhibit design plays in enhancing visitor experiences.

Recognizing this gap, Godinez and Fernandez (2019) emphasized the need for zoos to evaluate their educational and conservation contributions. While their review found extensive research on the effects of human-animal interactions, it identified a lack of studies examining how naturalistic exhibit design influences visitor perception. To address this, they recommended further research comparing non-visitors, first-time visitors, and repeat zoo-goers to assess how zoo visits shape public attitudes toward conservation over time.

This focus on visitor education also extends beyond direct encounters with animals. Spooner et al. (2019) investigated the impacts of wildlife and conservation education through theatre-based settings that do not include live animals. Their study explored the possibility of conservation education without compromising an animal's welfare (i.e. exclusion altogether) by comparing children's knowledge of conservation topics pre- and post-performance in a theatre setting. The researchers also suggested that excluding live animal encounters might improve public perceptions of zoos' commitment to animal welfare. However, this approach raises questions about the role of immersive, nature-based exhibit design in fostering deeper connections with wildlife. If the goal is to engage visitors and inspire conservation action, moving away from outdoor educational opportunities may not be the most effective strategy.

2.6 Effects of Nature Immersion for Humans

There has been a vast increase in research focusing on how the built environment impacts human health and behavior, but there is little overlap between *zoo design* and humans. There are prominent examples in recent years of research examining the human relationship with nature through various methods. Bowler et al. (2010) analyzed existing measurements of human health in synthetic and natural environments. Their study noted that natural environments can inherently improve overall health or well-being, as described by Kaplan and Kaplan's attention restoration theory and Ulrich's stress recovery theory. Being in a natural environment allows for enhanced cognitive performance and attention fatigue restoration, as well as improved positive emotions related to safety through adaptive responses to certain natural stimuli. Additional data to support these claims is provided by Bowler et al.'s analysis of 23 separate peer-reviewed articles. They found that many studies focused on measuring self-reported emotions (calmness, anger, sadness, etc) or physical effects, such as blood pressure or cortisol levels. These measures provided evidence that activity in nature, when compared with synthetic environments, positively affects energy and attention while reducing negative emotions like anger, fatigue, or sadness.

Similarly, Seymour (2016) combined theoretical and methodological approaches to create a deeper understanding of the factors involved in improving human health. A model was proposed detailing the relationships between human health and access to the natural environment. One specific study, Chiang et al. (2017), discussed the effects of locations and vegetation density on the human bodily response. Their study categorized landscape types as either 'wild nature' (native ecology only) or 'tended nature' (signs of human development). It was found that participants' stress and attention recovery levels were most significantly affected by the forest interior, suggesting that the more immersed in vegetation or a natural ecosystem, the better. Additionally, the results showed that people preferred areas with medium vegetation density rather than high or low, which supports the idea that both coverage *and* visibility within one's environment impact one's feeling of safety.

Kondo et al. (2018) determined that there is a consistent negative relationship between green space exposure and mortality, heart rate, and violence, and a consistent positive relationship with attention, mood, and physical activity. However, they found insignificant results regarding the impacts on weight, depression, and stress. They were able to conclude that more studies are necessary to fully understand the associations between access to green space and the resulting health outcomes.

To examine the potential of this concept in zoos, Rose and Riley (2022) discussed the newer concept of designing zoos for "green prescribing." In this study, the authors reviewed the idea that negative feelings are reduced by interaction with nature, especially in urban environments. While the authors called for expanded investigations on the actual impacts of zoos' efforts to address visitor well-being through access to nature, it was found that zoos could serve as restorative environments and be beneficial for mental and physical human health. Similar findings were reported by Sahlin et al. (2019), who explored the potential of zoos to foster positive impacts on visitor well-being, focusing on the relationship between participation in courses designed for people with disabilities and their caretakers and the participants' resulting health and well-being. Despite this, further research on more diverse demographics is needed to enhance the broader applicability of zoo design principles.

2.7 Research Gap and Study Significance

Research on the relationships between zoo design, conservation efforts, animal welfare and interactions, and visitor perception is all very recently developed in the scheme of zoo history, and there is a great disconnect between many studies based on their limitations of geographic region or demographic considerations. The largest focus of zoo research has been on animal welfare, husbandry, and visitors' perceptions of the animals, as well as the impacts of human-animal interactions within natural settings. Many studies highlight the importance of further research on the relationship between natural zoo design, human health, and zoo visitor perceptions. This study aims to fill the gap in research between evaluating zoo design efficacy and human experience in a synthetically built natural environment.

CHAPTER 3. METHODOLOGIES

This research utilized a quantitative approach in analyzing surveys collected from three zoos in Michigan, US. It aimed to provide insight into the relationships between natural zoo design elements and overall visitor satisfaction and affective mental state. The following section provides an in-depth description of the methods used in the study, including the research design, participant recruitment, measures, and data collection procedure.

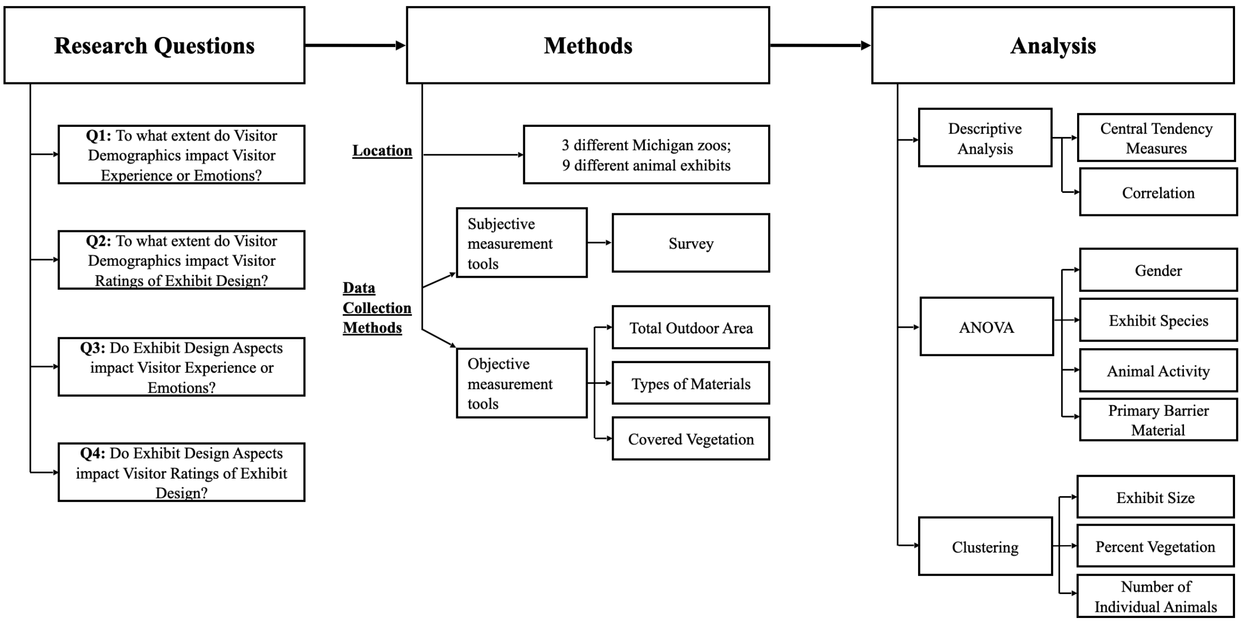

Figure 1. Summary of methodology processes

3.1 Participant Selection

Data was collected using a tablet provided by the MSU Health Scape Lab. IRB approval was obtained from MSU's Human Research Protection Program before beginning data collection. The participants for this study were recruited randomly at the three different exhibits rotationally during non-peak periods in each of the three zoos. Visitors over the age of 13 had an equal chance to participate in the study. Consent was obtained from each participant at the beginning of the survey to include their anonymous responses. To keep participation anonymous, signatures were *not* collected; instead, assent was given by checking a box. Anyone under the age of 13 was not allowed to participate. All participants approached were adults, but visitors between the ages of 13-17 were allowed to participate if accompanied by an adult. Age was verified with a guardian before beginning the consent process with any participants under the age of 18. I remained objective throughout the research, and all responses were anonymously collected. Following collection assured independence, participants were not exposed to any personal opinions or remarks from myself regarding the exhibits or zoos before taking the survey, ensuring the responses were not influenced by implicit bias.

3.2 Study Areas

All three locations were chosen based on their AZA-accreditation status, and on the following conditions to provide potential variety in zoo design quality based on their relative size and available funding: one large zoo, with large funding; one small to mid-sized zoo, with medium funding; and one small zoo, with relatively small funding. The internal revenue of each zoo ranges from $1.3 million to $50 million dollars per year. The number of animals housed in each zoo also ranges from 350 to over 2,000 individuals. The smallest zoo reported having around 200,000 visitors per year, while the largest zoo reported over one million visitors each year. The range of public outreach and financial support among the selected zoos allows for a stronger comparison of the results from each zoo. At each of the three zoos, three different exhibits were chosen for the study based on the following criteria: size, materials, amount of vegetation, and the actual species housed; this resulted in nine total study exhibits.

The species featured in each of the chosen exhibits needed to have similar draws to eliminate any potential bias towards exhibits with “more exciting” animals. In a study conducted by Carr in 2016, there was an analysis of peoples’ reasoning for picking their favorite or least favorite animals. Results showed that mammals, as opposed to birds, reptiles, amphibians, or invertebrates, are the preferred animals for most zoo visitors, as they are viewed as more charismatic and easier to connect with (Carr, 2016). Nearly 33% of respondents picked their favorite animal because it was active or interesting to watch and the number one response for an animal being someone’s *least* favorite was it being inactive or not easily visible (Carr, 2016). Subsequently, all the chosen exhibits for this thesis were diurnal or crepuscular mammal species. However, individual animal activity could not be controlled, so the researcher limited the days of survey collection to days with consistent weather conditions; between 60°F and 80°F, with no precipitation. Additionally, all the exhibits were open-air and the surveys were given in outdoor viewing areas.

Each of the selected exhibits was photographed and analyzed to gather the exhibit design variables, including total outdoor area, types of materials, and percent coverage by vegetation. It was important to measure the level of vegetation in two different ways. The first considers only the plants that originate within the exhibit boundaries, to consider visitors' perspective of the specific exhibit aspects. Then, to examine the overall effects of the vegetation levels on visitor experience and emotions, there was also consideration of the total amount of vegetation visible from the main exhibit viewing point. As seen in *Figures 2 and 3,* to measure the overall footprint of each exhibit, tools like Google Earth and the Kent County Parcel Mapper were used based on the visibility through the tree canopy on available satellite imagery. Each exhibit area was measured in square meters. This method has been used by many other researchers, as reviewed in depth by Tamiminia et al. (2020), to measure the area of small-scale environments using top-down GIS information from Google Earth.

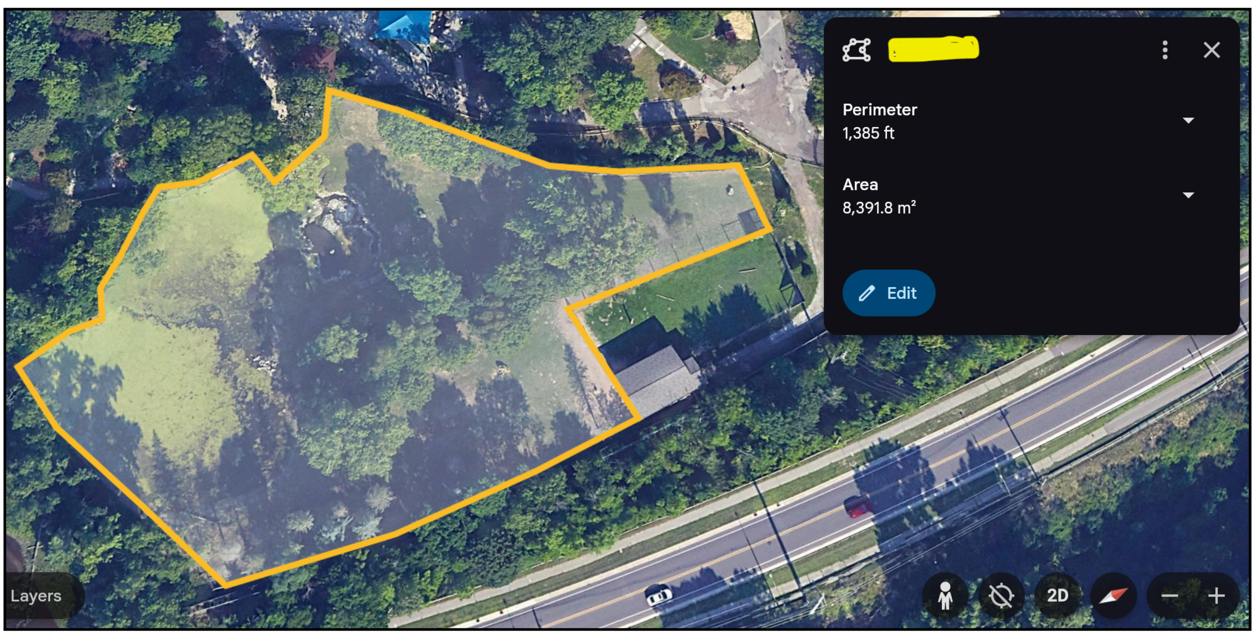

Figure 2. Example of measuring the area of an exhibit using Google Earth

Figure 3. Example of measuring the area of an exhibit using the Kent County Parcel Mapper

To measure the percent of area covered with vegetation in each exhibit, full panoramic images were constructed of the viewpoint from each survey location. The photos were taken during the time of the survey collection. The color contrast of each image was altered by adjusting the saturation of each color in the image to maximize the juxtaposition between vegetation (green) and other materials before adding a grayscale and running an *image trace* with the following parameters to create a black and white image in Adobe Illustrator, as seen in *Figures 4 and 5*. Adobe Illustrator *Image Trace Tool* - "Advanced Settings":

- **Mode:** Black and White
- **Threshold:** 50
- **Paths:** 100%
- **Corners:** 100%
- **Noise:** 100px

Figure 4. Example image of an exhibit produced in black and white only including the interior of the exhibit as visible from the survey location

Figure 5. Example image of an exhibit produced in black and white including the entire visible area from the survey location

Scientific imagining through Photoshop with Sedgwick's (2008) guidebook detailing the methods of separating relevant features from a background and measuring the outputs. After carefully generating the black and white images (*Figures 4 & 5*), where the black area represents vegetation and the white area represents any other material, the total number of pixels in the image was counted using the Adobe Photoshop 'selection' and 'measurement' tools. Then the number of black pixels was counted using the same tools. The percent area covered by black pixels (aka vegetation) could then be calculated. For data analysis, two different measures of vegetation percentage were calculated. First was the amount of vegetation originating *within* the exhibit, as seen in *Figure 4*. For this, any area or vegetation visible outside the exhibit barriers was excluded from the overall area, as marked by the grey color. The second calculation included the entire visible area of the exhibit from the survey location, as seen in *Figure 5*. An example of Adobe Photoshop output measurements, including the area of the image in pixels, can be seen in *Table 2*. The full results of these visual analyses are listed in *Table 3*.

E	F	G	H	I	J	K	L	M
Scale	Scale Units	Scale Factor	Count	Area	Perimeter	Circularity	Height	Width
1 pixel(s) = 1.	pixels	1	43	2466733	43427.4272	0.016436	1560	2702

Table 2. Example table of measurements of an image in Adobe Photoshop

The following *Table* (*3*) describes the calculated parameters (size, percent vegetation, materials, etc) of each of the study exhibits, labeled *A-I*. The primary barrier material describes what material makes up the barriers between visitors and the animals. The exhibits used either glass windows, wooden fencing, concrete, rope/wire netting, or a combination thereof.

Exhibit Summary							
Exhibit	Species	# Individual Animals	Area (m²)	# of Viewpoints	**Primary** Barrier Material(s)	Percent Vegetation (Interior exhibit only)	Percent Vegetation (+ Exterior exhibit)
A	N.A. River Otter	4	292 ± 14.6	3	**glass**, wood	84.6993 ± 5%	77.0912 ± 5%
B	Canadian Lynx	2	134 ± 6.7	1	**wood**, wire	18.9047 ± 5%	45.4533 ± 5%
C	Elk	7	8,094 ± 404.7	2	**wood**, wire	57.6272 ± 5%	43.3278 ± 5%
D	N.A. River Otter	2	232 ± 11.6	2	**wood**, wire	25.8894 ± 5%	54.8022 ± 5%
E	Grey Wolf	2	7,711 ± 385.6	4	**glass**, wood, concrete	94.5096 ± 5%	44.3249 ± 5%
F	Grevy's Zebra	5	6,782 ± 339.1	3	**wood**, concrete	94.366 ± 5%	60.8407 ± 5%
G	N.A. River Otter	2	147 ± 7.4	3	**glass**, steel, wood	8.3349 ± 5%	46.4871 ± 5%
H	Canadian Lynx	4	129 ± 6.5	2	**wood**, wire	4.8946 ± 5%	50.8597 ± 5%
I	Mountain Bongo	3	1251 ± 62.6	3	**wood**, concrete	82.6151 ± 5%	57.257 ± 5%

Table 3. Calculated or determined exhibit parameters

3.3 Research Questions and Hypotheses

There are four main questions of interest being investigated by this study, relating four groups of variables as follows. The full table of variables is provided in *Section 3.4*.

1. Question: To what extent do visitor demographics impact their experience and emotional response in a zoo setting?
    - Hypothesis: It is hypothesized that some groups may tend to rate higher on questions about their experience or emotions due to implicit bias or previous experience.
        - Prediction: Older or more frequent visitors will rate more positively regarding their experiences and emotions
2. Question: To what extent do visitor demographics impact visitor *impressions* of exhibit design?
    - Hypothesis: It is again believed that some groups may tend to rate higher on questions about their perceptions of the exhibits due to implicit bias or previous experience.
        - Prediction: More experienced zoo visitors will have better understanding of zoo efforts and operations, and higher ratings for their impressions of certain zoo design aspects based on the the evidence found in the literature review *Section 2.5*.
3. Question: Does enclosure design impact visitor experience or emotional response?
    - Hypothesis: It is hypothesized that exhibits that better mimic that natural environment will evoke more positive experiences and emotional responses.
        - Prediction: Larger exhibits with denser vegetation and more invisible barriers will improve visitor experience or emotions based on the evidence found in the literature review *Section 2.6*.
4. Does enclosure design impact visitor *impressions* of exhibit design?
    - Hypothesis: It is hypothesized that exhibits that better mimic that natural environment will leave better impressions of the zoo and its design impacts.

- Prediction: Larger exhibits with denser vegetation and better visitor immersion through ‘invisible’ barriers, like glass, might improve visitor impressions of the design and animal welfare of the individuals in the exhibit. This prediction is based on the evidence found in the literature review *Section 2.5*. I am also curious as to *which* specific design aspects have the most significant impact on the visitor's impressions of exhibit design.

3.4 Research Implement

In this research, four categories of variables were studied through online surveys. These variables are: participant demographics, enclosure design aspects, visitor perceptions of the zoo and enclosure design, and visitor affective mental state. *Table 4* demonstrates the different variables belonging to each of these categories. The survey was developed and subsequently analyzed using Qualtrics. To ensure internal validity, the questions were developed based on the objectives of the research. Each important variable and its potential relationships with others were considered in the question design. The survey was pilot-tested before launching at the zoos. Feedback from the pilot tests was used to refine the question design for user clarity and to eliminate any anticipated technical difficulties. Each of the zoos was allowed to provide feedback on the survey development before launching, and some of the question wording was altered according to their responses.

Independent Variables		Dependent Variables	
Visitor Demographics	**Exhibit Design Aspects**	**Visitor Experience/ Emotions**	**Visitor Impression of Exhibit Design**
- Age - Gender - Education Level - Distance Traveled - Visit Frequency - # Other Zoos Visited - How Much Do You Like the Animal? (Predisposition)	- Species - # Individuals - Exhibit Size - # Viewpoints - Exhibit Materials - Vegetation Level (Overall) - Vegetation Level (Interior Exhibit) - Animal Activity (varies by participant)	- Overall Visit - Likelihood to Return - Animal Welfare Rating - Stress Level - Happiness Level - Sadness Level - Excitement Level - Anger Level - Relaxation Level	- Overall Zoo Design - Animals' Benefit from Design - Visitors' Benefit from Design - Exhibit Satisfaction - Exhibit Size Rating - Exhibit Materials Rating - Exhibit Vegetation Rating - Animal Visibility Rating

Table 4. Categorized variables included in the survey

Identical surveys were used for every enclosure. With specific permission from each zoo, the surveys were collected in person by the researcher over four months, from June through September of 2024. It is important to note that conditions may be different in various seasons due to Michigan's climate, and one of the zoos is closed to the public during the winter. To limit the impacts of weather on survey responses, the researcher only collected data on mild to warm days (60-80°F) with no precipitation. See *Appendix I* for the full survey.

3.5 Data Analysis

After collecting all the survey responses, the answers to each question were coded and simplified within Qualtrics to conduct correlation, cluster, and ANOVA statistical analyses comparing the main independent variables: visitor demographics, and enclosure design aspects; with the main dependent variables: visitor experience, emotions, and perceptions of exhibit design aspects. Each variable was categorized by research question and tested across each other to find any possible significant relationships. A comparison of assumed correlated variables was conducted to ensure the internal validity of the survey and the reliability of the responses. The following *Chapter (4)* will detail the results.

CHAPTER 4. RESULTS

Understanding visitor demographics and their experiences is essential for improving zoo exhibit design and enhancing overall visitor satisfaction. This section examines survey responses from 187 visitors across three different zoos, focusing on demographic trends, visitation patterns, and factors influencing visitor emotions and perceptions of exhibit design. Through statistical analyses, including correlation tests, ANOVA, and clustering methods, I explored how variables such as age, education, travel distance, and species affinity impact visitor experiences. By identifying significant relationships between exhibit characteristics and visitor engagement, my findings offer valuable insights for optimizing zoo environments to better meet visitor expectations and improve overall zoo experiences.

		Zoo 1 Exhibits				Zoo 2 Exhibits				Zoo 3 Exhibits		
	Zoo 1	**A**	**B**	**C**	**Zoo 2**	**D**	**E**	**F**	**Zoo 3**	**G**	**H**	**I**
# Responses	61	19	21	21	62	20	21	21	64	22	19	23

Table 5. Total number of responses received at each zoo and individual exhibits

4.1 Descriptive Results

I surveyed a large demographic of visitors, and the exhibits themselves provided a wide range of exhibit design aspects. The following *Table (6)* details the mean, median, mode, and standard deviation for every numeric variable. According to survey responses, the average visitor age was 39.6 years, and the average distance traveled to the zoo by each visitor was 21.96 miles. Most respondents reported having visited at least three other zoos previously, giving some points of comparison for their reflections. The average visitor ratings for overall experience (4.60/5.0), likelihood to return (4.68/5.0.), and animal welfare (4.42/5.0) lend to the idea that the selected zoos are proper examples of the AZA standards for zoo operations. Average ratings of animals' benefits (4.31/5.0) and visitors' benefits (4.47/5.0) from exhibit design reveal that visitors do perceive the positive impacts of zoo design, both for the animals and the people interacting with the space. The average rating for all three positive emotional states (happiness, excitement, and relaxation) was greater than 4.0/5.0, and the average rating for all three negative emotional states (stress, sadness, and anger) was less than 2.5/5.0. Ratings for exhibit size, vegetation level, materials, and animal visibility were all greater than 4.0/5.0.

Central Tendency Measures				
Variable	**Mean**	**Median**	**Mode**	**SD**
Exhibit Size Measurement (m^2)	2790.3048	292.0000	1251.0000	3418.9863
# Individual Animals	3.4278	3.0000	2.0000	1.6523
# Viewpoints	2.8930	3.0000	3.0000	0.8795
% Vegetation (Interior Exhibit Only)	53.1530	50.8591	57.2570	9.9884
% Vegetation (Entire Viewing Area)	52.8190	57.6272	82.6151	35.8308
Age	39.5989	25.0000	25.0000	16.6954
Distance Traveled (mi)	21.9626	16.0000	45.0000	18.3157
Visit Frequency (/year)	4.1444	1.0000	1.0000	8.1475
# Other Zoos Visited	4.5936	3.0000	3.0000	3.1187
Like the Animal? (1-5)	4.6684	5.0000	5.0000	0.5932
Overall Experience (1-5)	4.6043	5.0000	5.0000	0.6422
Likelihood to Return (1-5)	4.6791	5.0000	5.0000	0.7990
Animal Welfare Rating (1-5)	4.4225	5.0000	5.0000	0.7392
Stress Level (1-5)	1.3636	1.0000	1.0000	0.7872
Happiness Level (1-5)	4.4866	5.0000	5.0000	0.7575
Sadness Level (1-5)	1.3850	1.0000	1.0000	0.8304
Excitement Level (1-5)	4.0481	4.0000	5.0000	0.9463
Anger Level (1-5)	2.2246	1.0000	1.0000	2.8891
Relaxation Level (1-5)	4.2139	4.0000	5.0000	0.8964
Overall Zoo Design Rating (1-5)	4.5348	5.0000	5.0000	0.6414
Animals' Benefit from Design Rating (1-5)	4.3102	5.0000	5.0000	0.8676
Visitors' Benefit from Design Rating (1-5)	4.4706	5.0000	5.0000	0.7427
Specific Exhibit Design Rating (1-5)	4.5668	5.0000	5.0000	0.6304
Size Rating (1-5)	4.3262	5.0000	5.0000	0.8953
Materials Rating (1-5)	4.5989	5.0000	5.0000	0.6757
Vegetation Rating (1-5)	4.3369	5.0000	5.0000	0.8481
Animal Visibility Rating (1-5)	4.4759	5.0000	5.0000	0.8381

Table 6. Central tendency measures: mean, median, mode, and standard deviation for numerical variables

A total of 187 visitors participated in the survey across the three different zoos. Several observations were made in general regard to visitors who were willing to take the survey. Many times, when there were groups of both men and women approached and asked if any individuals were willing to participate, female respondents were more willing to contribute than males. This is reflected in the gender demographic of survey participants, as seen in *Figure 6.* The survey results indicate a slightly larger proportion of female participants (64.17%) than predicted. These results do not align with the documented gender demographics of zoo visitors in general, as the AZA (2021) reports that about 54% of zoo visitors identify as female.

There was usually decline from single parents who had small children with them, due to either the kids' lack of patience in waiting at one exhibit for long or the parents' natural unwillingness to pull their attention away from the kids. However, there is no evidence that this may have affected the demographic variable, as the age demographic of survey participants, as seen in *Figure 7*, seems to align with the documented age demographics of zoos in general (AZA, 2021). Participants were not asked whether they had children with them at the zoo, so this was not a focus variable. The education level of all participants is shown in *Figure 8.* More than half of the participants reported having an associate's degree or higher.

Visitors reported traveling various distances to the zoo. The largest proportion of respondents (33.16%) traveled more than 45 miles, as seen in *Figure 9.* However, a larger combined proportion of respondents (40.64%) also reported traveling less than 5 or 10 miles. It was found that a lot of respondents had either never visited that specific zoo before (24.04%) or only visited once per year (37.97). Very few respondents reported visiting that zoo once per month or more (11.23%). These results are shown in *Figure 10*. However, most respondents seemed to be avid zoo-goers, with 79.67% of respondents having visited more than three other zoos. This is seen in *Figure 11*.

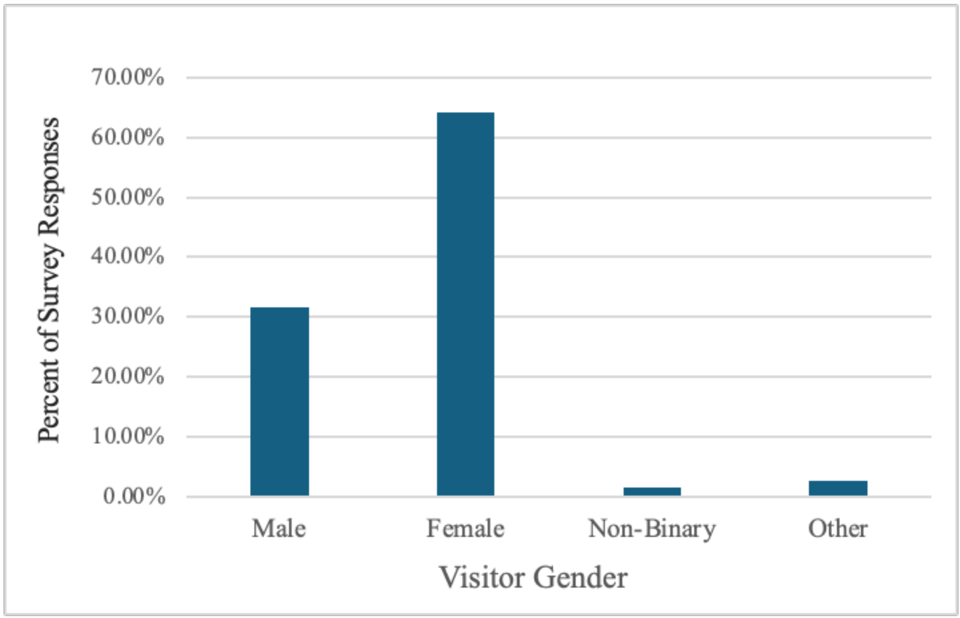

Figure 6. Gender Demographic of Survey Participants

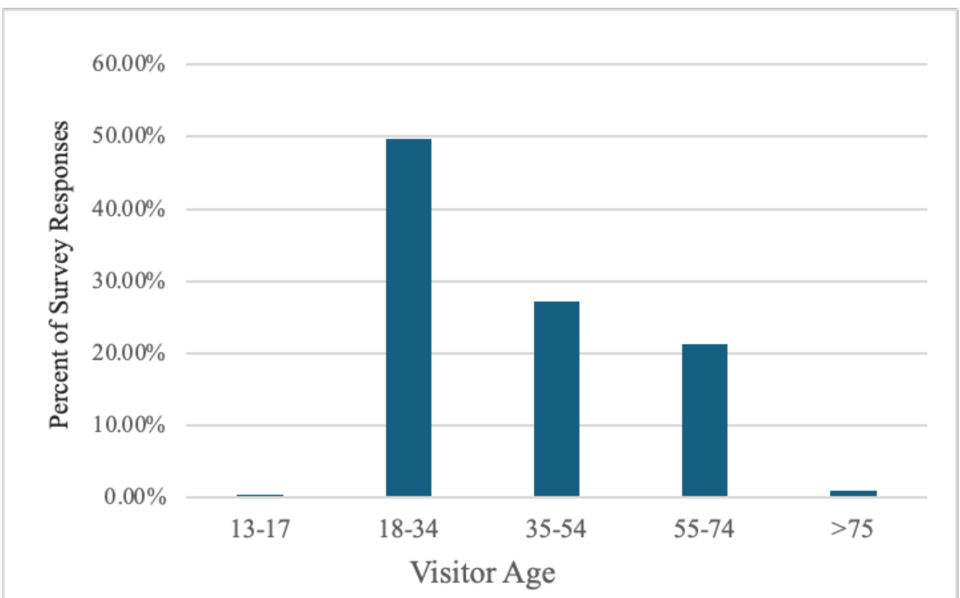

Figure 7. Age Demographic of Survey Participants

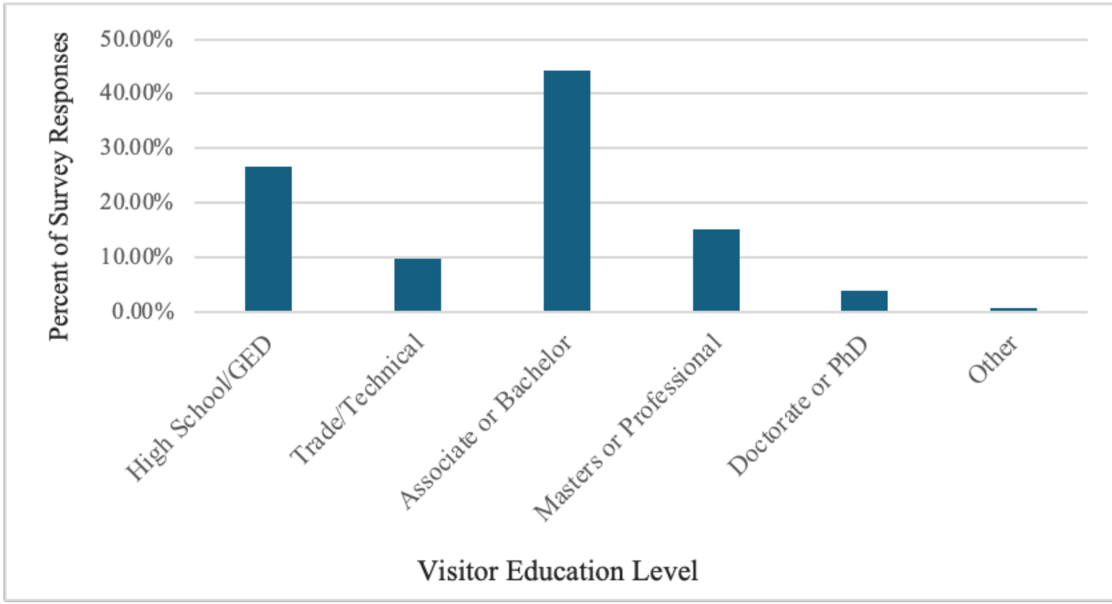

Figure 8. Education Level of Survey Participants

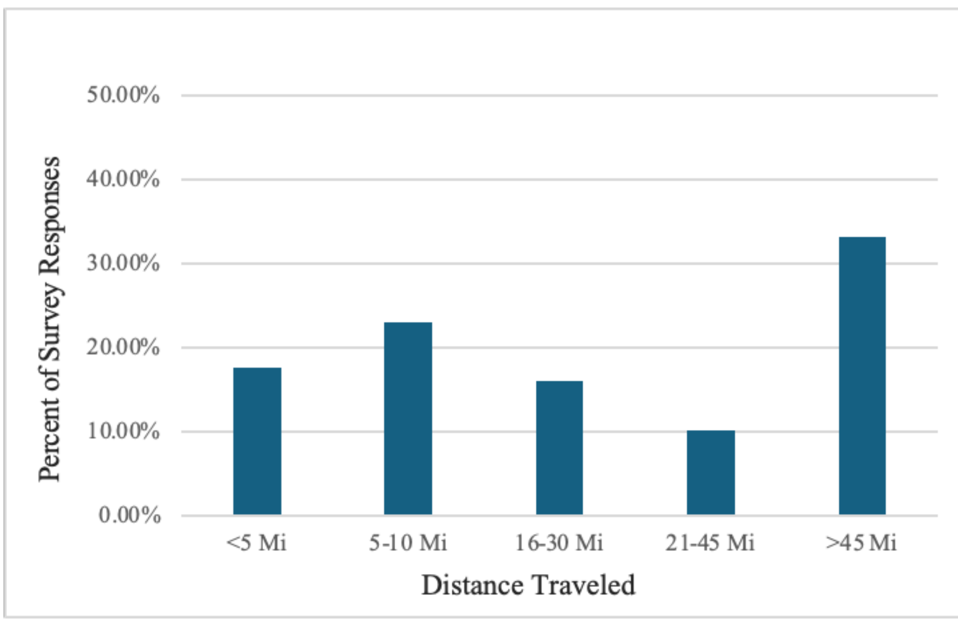

Figure 9. Distance traveled by survey participants to the zoo at which they responded

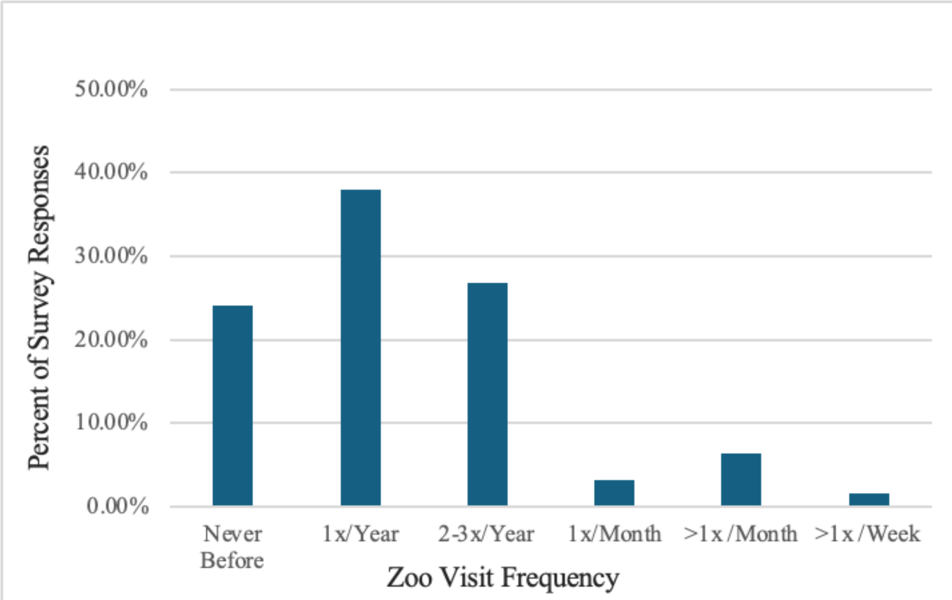

Figure 10. Visit frequency of survey participants to the zoo at which they responded

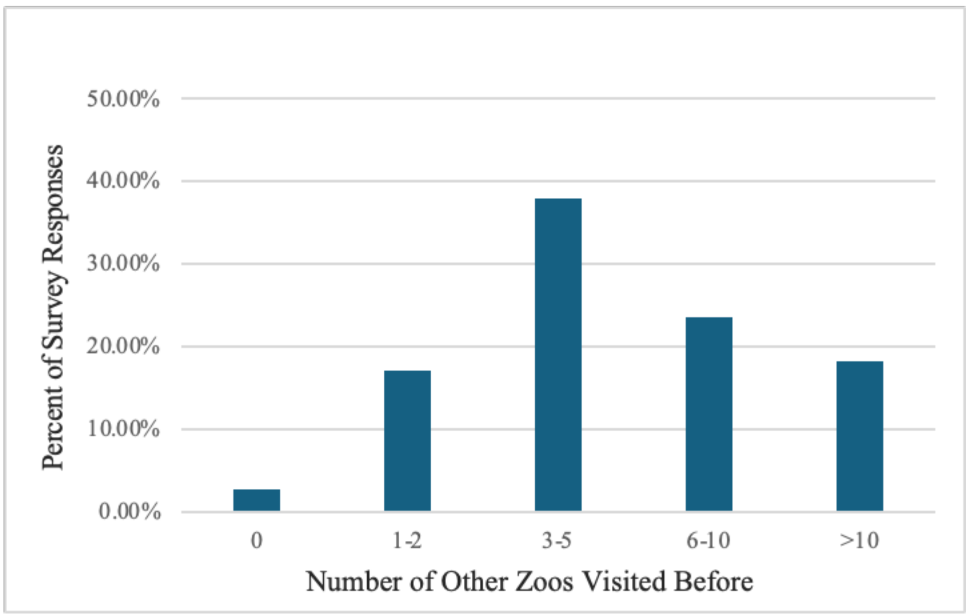

Figure 11. Number of other zoos visited by survey participants

4.2 Correlation Test Results

Correlation testing was conducted to identify any significant relationships between demographic variables. These results are shown in *Table 7.* It was found that age and number of other zoos visited were slightly positively correlated, r^2 = [0.0524], p = [0.0016], which can be interpreted as older visitors being more likely to have visited a higher number of other zoos. Education level was also slightly positively correlated with the number of other zoos visited, r^2 =

[0.0353], p = [0.0100], with respondents having higher levels of education having visited more zoos on average. This could be potentially attributed to varying socioeconomic status and visitors' ability to afford many zoo visits. An additional slightly positive correlation was seen between the distance traveled to the zoo and the number of other zoos visited, r^2 = [0.0458], p = [0.0033]. These relationships demonstrate that visitors who traveled farther are more likely to have been to a higher number of other zoos. While these results are all significant ($p < 0.05$), the effect size (r) in each case never reaches ±0.5, meaning the correlations themselves are not the strongest.

Inter-relationships b/t Demographic Variables							
Independent Variable	**Dependent Variable**	**Test Type**	**Effect Size [r]**	**r^2**	**Confidence Interval**	**P-Value**	**Sample Size [n]**
Visitor Age	# Other Zoos Visited	Correlation	0.229	0.0524	[0.0886, 0.361]	0.00160	187
Visitor Education Level	# Other Zoos Visited	Correlation	0.188	0.0353	[0.0457, 0.323]	0.01000	186
Distance Traveled	# Other Zoos Visited	Correlation	0.214	0.0458	[0.0729, 0.347]	0.00325	187

Table 7. Significant results from correlation tests comparing visitor demographic variables to each other

Correlation testing was also conducted to analyze the impacts of visitor demographics on visitor experience, emotions, and ratings of exhibit design. The significant results are shown in *Table 8.* There were slight negative correlations between visitor age and excitement level, r^2 = [0.0328], p = [0.0133], as well as between the number of other zoos visited and sadness level, r^2 = [0.0400], p = [0.0061]. These results demonstrate that older visitors are less likely to be excited by an exhibit, and regular zoo-goers are more likely to be saddened by an exhibit. Again, while these results are all significant, the effect size (r) in each case never reaches ±0.5, meaning the correlations themselves are not the strongest. The only demographic variable that impacted visitor ratings of exhibit design was visitor education level, r^2 = [0.0272], p = [0.0248]. The slight positive correlation indicates that visitors who have completed a higher level of education are more likely to perceive the benefits of exhibit design for zoo visitors. There were no other significant results relating visitor demographics to ratings of exhibit design.

(RQ1 & 2) Impacts of Demographics on Visitor Responses							
Independent Variable	**Dependent Variable**	**Test Type**	**Effect Size [r]**	**r^2**	**Confidence Interval**	**P-Value**	**Sample Size [n]**
Visitor Age	Excitement Rating	Correlation	-0.181	0.0328	[-0.316, -0.0383]	0.01330	187
# Other Zoos Visited	Sadness Rating	Correlation	-0.2	0.04	[-0.334, -0.0582]	0.00607	187
Visitor Education Level	Visitors' Benefit from Design Rating	Correlation	0.165	0.0272	[0.0212, 0.301]	0.02480	186

Table 8. Significant results from correlation tests relating visitor demographics to visitor experience, emotions, and ratings of exhibit design

Correlation testing was also conducted to analyze whether participants' affinity for the species in their selected exhibits played a part in their overall experience and emotions. Respondents were asked to rate how much they like the animals on a scale of 1-5, with 5 being the highest, and these results were compared with all the visitor experience and emotion variables. The significant results from these tests are listed in *Table 9.* There was a fairly strong positive correlation between how much visitors liked the animal(s) and their overall experience ratings, $r^2 = [0.2798]$, $p < [0.00001]$. This means visitors who personally like the exhibit species more are more likely to have a more positive overall experience. There were also slight positive correlations between how much visitors liked the animal and visitor happiness levels, $r^2 = [0.0955]$, $p < [0.00001]$, and between animal affinity and visitor excitement levels, $r^2 = [0.1739]$, $p < [0.00001]$. Slight positive correlations were also found between how much visitors liked the animal and the animal welfare ratings, $r^2 = [0.0955]$, $p = [0.00002]$, and between animal affinity and visitor relaxation levels, $r^2 = [0.0566]$, $p = [0.00104]$. These results indicate that visitor emotions and perceptions of animal welfare are likely to improve with more well-liked species.

Impacts of Visitor Animal Affinity on Experience/Emotions							
Independent Variable	**Dependent Variable**	**Test Type**	**Effect Size [r]**	**r²**	**Confidence Interval**	**P-Value**	**Sample Size [n]**
"How much do you like the animal?"	Overall Experience	Correlation	0.529	0.2798	[0.417, 0.625]	<0.00001	187
	Animal Welfare Rating	Correlation	0.309	0.0955	[0.173, 0.433]	0.00002	187
	Happiness Rating	Correlation	0.417	0.1739	[0.291, 0.529]	<0.00001	187
	Excitement Rating	Correlation	0.45	0.2025	[0.328, 0.558]	<0.00001	187
	Relaxation Rating	Correlation	0.238	0.0566	[0.0978, 0.369]	0.00104	187

Table 9. Significant results from correlation tests relating how much visitors like the animals to visitor experience and emotions

Some visitor ratings of exhibit design were also significantly impacted by visitors' affinity for the subject species. These results are shown in *Table 10.* Slight positive correlations were found in most cases, meaning that more likable species are likely to improve the visitor perception of all exhibit design aspects. The strongest correlation was seen between how much visitors liked the animal and exhibit satisfaction ratings, $r^2 = [0.1640]$, $p < [0.00001]$. This indicates that animal likability has the strongest impact on overall visitor satisfaction with an exhibit as compared to other specific exhibit design ratings.

Impacts of Visitor Animal Affinity on Ratings of Design							
Independent Variable	**Dependent Variable**	**Test Type**	**Effect Size [r]**	**r²**	**Confidence Interval**	**P-Value**	**Sample Size [n]**
"How much do you like the animal?"	Visitors' Benefit from Design Rating	Correlation	0.295	0.0870	[0.158, 0.421]	0.00004	187
	Animals' Benefit from Design Rating	Correlation	0.316	0.0999	[0.180, 0.439]	0.00001	187
	Exhibit Satisfaction Rating	Correlation	0.405	0.1640	[0.277, 0.518]	<0.00001	187
	Exhibit Materials Rating	Correlation	0.351	0.1232	[0.218, 0.470]	<0.00001	187
	Animal Visibility Rating	Correlation	0.319	0.1018	[0.184, 0.442]	<0.00001	187

Table 10. Significant results from correlation tests relating how much visitors like the animals to visitor ratings of exhibit design

All numerical exhibit design variables were compared to the visitor experience and emotions through correlation testing. The significant results are shown in *Table 11*. Significant results include slight negative correlations between the number of individual animals and visitor excitement level, $r^2 = [0.0433]$, $p < [0.0045]$, and between the measured exhibit size and visitor excitement level, $r^2 = [0.0751]$, $p < [0.0002]$. There was also a slight positive correlation between the percent of vegetation visible from the main exhibit viewing area and the overall visitor experience, $r^2 = [0.0269]$, $p < [0.0256]$. The negative correlations indicate that excitement level is likely to decrease with an increase in exhibit size and the number of individual animals in the exhibit. These findings are contradictory to the hypothesis that larger exhibits would be favorable to visitors. Again, while these results are all significant, the effect size (r) in each case never reaches ±0.5, meaning the correlations themselves are not the strongest.

(RQ3) Impacts of Design Aspects on Visitor Experience/Emotions							
Independent Variable	**Dependent Variable**	**Test Type**	**Effect Size [r]**	**r^2**	**Confidence Interval**	**P-Value**	**Sample Size [n]**
# Individual Animals	Excitement Rating	Correlation	-0.208	0.0433	[-0.341, -0.0658]	0.00445	186
Exhibit Size Measurement	Excitement Rating	Correlation	-0.274	0.0751	[-0.401, -0.136]	0.00015	186
% Vegetation (Entire Viewing Area)	Overall Experience	Correlation	0.164	0.0269	[0.0203, 0.301]	0.02560	186

Table 11. Significant results from correlation tests relating designed exhibit aspects to visitor experience and emotions

The numerical measured exhibit aspects were also compared to visitor ratings of exhibit design through correlation tests. These results are shown in *Table 12*. Slight positive correlations were found between animal visibility ratings and the number of individual animals, $r^2 = [0.0246]$, $p < [0.0318]$. These results indicate that exhibits with more individual animals are likely to improve animal visibility. The percent of vegetation in the exhibit interior was slightly positively correlated with exhibit vegetation ratings, $r^2 = [0.0228]$, $p < [0.0397]$, which indicates that denser vegetation within an exhibit is likely to improve visitor ratings of exhibit vegetation.

(RQ4) Impacts of Design Aspects on Ratings of Design							
Independent Variable	**Dependent Variable**	**Test Type**	**Effect Size [r]**	**r²**	**Confidence Interval**	**P-Value**	**Sample Size [n]**
# Individual Animals	Animal Visibility Rating	Correlation	0.157	0.0246	[0.0139, 0.295]	0.03180	186
% Vegetation (Exhibit Interior Only)	Exhibit Vegetation Rating	Correlation	0.151	0.0228	[0.00726, 0.289]	0.03970	186

Table 12. Significant results from correlation tests relating measured exhibit design aspects to visitor ratings of exhibit design

4.3 ANOVA Test Results

Regarding their emotions, visitors were asked if they agreed with statements regarding the impact of exhibit design on varying emotions on a five-point scale from "completely disagree" to "completely agree". See the full survey (*Appendix I*) for the specific question-wording. Because gender is categorized rather than measurable, a one-way ANOVA was conducted to examine the effect of visitor gender on visitor experience, emotions, and ratings of exhibit design. The analysis revealed a medium significant effect of gender on visitor excitement level, p = [0.0197], f = [0.234], indicating that those who identified as female tended to rate the exhibit's impact on their excitement level higher (4.16/5.0) than those who identified as male (3.78/5.0). Respondents who identified as non-binary always selected the highest possible rating for excitement level, but the small sample size of that specific group (n=3) should be highly considered. No other tests here yielded significant results.

(RQ1) Impacts of Gender on Visitor Experience/Emotions						
Dependent Variable	**Gender of Participant**	**Sample Size [n]**	**Mean**	**SD**	**Effect Size [f]**	**P-value**
Excitement Level	Male	59	3.78	1.07	0.234	0.0197
	Female	120	4.16	0.86		
	Non-Binary	3	5.00	0.00		

Table 13. Significant results from ANOVA tests relating visitor gender to visitor experience and emotions

A one-way ANOVA was also conducted to examine the effect of exhibit species on visitor experience, emotions, and ratings of exhibit design. All significant results are shown in *Table 14.*

The analysis revealed a significant medium impact of exhibit species on visitor excitement levels, p = [0.00103], f = [0.382], indicating that smaller carnivorous species, like otters, lynx, and wolves, had higher average excitement ratings than the larger ungulate species, including elk, zebra, and bongos. The analysis also revealed a medium significant effect of exhibit species on ratings for animals' benefit from exhibit design, p = [0.0191], f = [0.284], indicating that exhibits with elk, wolves, or otters tended to have higher ratings of animals' benefits from design than exhibits with the other selected species. The analysis also revealed a medium significant effect of exhibit species on ratings for exhibit satisfaction, p = [0.0064], f = [0.283], indicating that exhibits with elk, wolves, or otters tended to have higher ratings of exhibit satisfaction than other selected species. The analysis also revealed a medium significant effect of exhibit species on ratings for exhibit size, p = [0.0022], f = [0.341], indicating that exhibits with elk, wolves, or otters tended to have higher ratings of exhibit size than other selected species. However, these relationships could also be potentially explained by the differences in the exhibit design among the species. For example, the larger ungulate species were housed in much larger exhibits than the smaller species like otters or lynx.

(RQ3 & 4) Impacts of Exhibit Species on Survey Responses						
Dependent Variable	**Exhibit Species**	**Sample Size [n]**	**Mean**	**SD**	**Effect Size [f]**	**P-value**
Excitement Level	Otter	61	4.38	0.73	0.382	0.00103
	Lynx	39	4.15	0.87		
	Elk	21	3.52	1.12		
	Wolf	21	4.10	0.83		
	Zebra	21	3.43	0.98		
	Bongo	23	3.96	1.07		
Animals's Benefit from Design Rating	Otter	61	4.43	0.85	0.284	0.0191
	Lynx	39	4.15	0.84		
	Elk	21	4.67	0.66		
	Wolf	21	4.43	0.93		
	Zebra	21	3.86	0.96		
	Bongo	23	4.30	0.82		
Exhibit Satisfaction	Otter	61	4.66	0.54	0.283	0.00635
	Lynx	39	4.33	0.66		
	Elk	21	4.86	0.48		
	Wolf	21	4.57	0.75		
	Zebra	21	4.48	0.75		
	Bongo	23	4.52	0.59		
Exhibit Size Rating	Otter	61	4.48	0.83	0.341	0.0022
	Lynx	39	3.92	0.93		
	Elk	21	4.67	0.73		
	Wolf	21	4.52	0.98		
	Zebra	21	4.1	0.89		
	Bongo	23	4.3	0.88		

Table 14. Significant results from ANOVA tests relating exhibit species to visitor experience, emotions, and ratings of exhibit design

A one-way ANOVA was conducted to examine the effect of animal activity on visitor experience, emotions, and ratings of exhibit design. First, the analysis revealed a small significant effect of animal activity on overall experience, p = [0.02000], f = [0.219], indicating that exhibits with active animals or mixed (active and inactive) tended to have higher ratings for overall visitor experience than exhibits with inactive animals. The analysis also revealed a medium significant effect of animal activity on the likelihood to return, p = [0.00174], f = [0.292], indicating that exhibits with active animals or mixed (active and inactive) tended to have higher ratings for likelihood to return than exhibits with inactive animals. The analysis also revealed a small significant effect of animal activity on visitor happiness, p = [0.00601], f = [0.238], indicating that exhibits with active animals or mixed activity (inactive and active) had higher average ratings for visitor happiness than exhibits with inactive animals. The analysis also revealed a medium significant effect of animal activity on visitor excitement, p = [0.00212], f = [0.274], indicating that exhibits with active animals or mixed activity (inactive and active) had higher average ratings for visitor excitement than exhibits with inactive animals.

Regarding the impacts of animal activity on visitor ratings of exhibit design, the analysis revealed a medium significant effect of animal activity on exhibit satisfaction, p = [0.00703], f = [0.25], indicating that exhibits with active animals or mixed activity (inactive and active) had higher average ratings for exhibit satisfaction than exhibits with inactive animals. The analysis also revealed a small significant effect of animal activity on animal visibility ratings, p = [0.04180], f = [0.187], indicating that exhibits with active animals or mixed activity (inactive and active) had higher average ratings for animal visibility than exhibits with inactive animals. These findings indicate that visitors are more likely satisfied by active animals and that animal inactivity can lead to visibility issues.

Impacts of Animal Activity on Survey Responses						
Dependent Variable	**Animal Activity**	**Sample Size [n]**	**Mean**	**SD**	**Effect Size [f]**	**P-value**
Overall Experience	Active	79	4.71	0.53	0.219	0.02
	Inactive	74	4.43	0.74		
	Mixed (Active/Inactive)	34	4.74	0.57		
Likelihood to Return	Active	79	4.77	0.78	0.292	0.00174
	Inactive	74	4.47	0.92		
	Mixed (Active/Inactive)	34	4.91	0.29		
Happiness Level	Active	79	4.59	0.71	0.238	0.00601
	Inactive	74	4.28	0.84		
	Mixed (Active/Inactive)	34	4.71	0.52		
Excitement Level	Active	79	4.22	0.87	0.274	0.00212
	Inactive	74	3.74	1.01		
	Mixed (Active/Inactive)	34	4.32	0.81		
Exhibit Satisfaction	Active	79	4.70	0.49	0.25	0.00703
	Inactive	74	4.36	0.73		
	Mixed (Active/Inactive)	34	4.71	0.58		
Animal Visibility Rating	Active	79	4.63	0.74	0.187	0.0418
	Inactive	74	4.32	0.92		
	Mixed (Active/Inactive)	34	4.44	0.82		

Table 15. Significant results from ANOVA tests relating animal activity to visitor experience, emotions, and ratings of exhibit design

A one-way ANOVA was also conducted to examine the effect of exhibit materials on visitor experience, emotions, and ratings of exhibit design. First, the analysis revealed a small significant effect of animal activity on the overall experience, p = [0.00583], f = [0.224], indicating that exhibits with glass barriers had higher average ratings for overall experience than other materials. This could be potentially explained by the perceived invisibility of glass, more effectively immersing visitors in the exhibit design. The analysis also revealed a small significant effect of exhibit materials on exhibit satisfaction, p = [0.05100], f = [0.193], indicating that exhibits with wood or glass as the primary barrier material had higher average ratings for exhibit satisfaction than exhibits utilizing wire or netting. The analysis also revealed a medium significant effect of exhibit materials on exhibit size ratings, p = [0.00028], f = [0.305], indicating that exhibits with glass as the primary barrier material had higher average ratings for exhibit size than other materials. The analysis also revealed a small significant effect of exhibit materials on exhibit vegetation ratings, p = [0.03510], f = [0.175], indicating that exhibits utilizing glass had higher average ratings for exhibit vegetation than exhibits with other materials.

(RQ3 & 4) Impacts of Exhibit Materials on Survey Responses						
Dependent Variable	**Primary Barrier Material**	**Sample Size [n]**	**Mean**	**SD**	**Effect Size [f]**	**P-value**
Excitement Level	Wood	108	3.88	1.00	0.224	0.00583
	Glass	39	4.38	0.75		
	Wire/Netting	39	4.15	0.87		
Exhibit Satisfaction	Wood	108	4.63	0.59	0.193	0.051
	Glass	39	4.62	0.67		
	Wire/Netting	39	4.33	0.66		
Exhibit Size Rating	Wood	108	4.36	0.86	0.305	0.000277
	Glass	39	4.62	0.85		
	Wire/Netting	39	3.92	0.93		
Exhibit Vegetation Rating	Wood	108	4.25	0.91	0.175	0.0351
	Glass	39	4.62	0.71		
	Wire/Netting	39	4.28	0.76		

Table 16. Significant results from ANOVA tests relating exhibit barrier materials to visitor experience, emotions, and ratings of exhibit design

4.4 Clustering Analysis Results

Clustering analysis was performed to better measure the relationships between numerical variables. The following measured exhibit design aspect variables were further analyzed in clusters: exhibit size, percent vegetation (interior exhibit only), percent vegetation (entire viewing area), and the number of individual animals in the exhibit. The Elbow Method was used in each case to determine the optimal number of clusters. For all four variables, the optimal number of clusters was determined to be three, as seen in *Figures (12), (13), (14),* and *(15).*

Then, each of the clustered variables was tested across each of the dependent variables through ANOVA testing to examine any potential statistical relationships.

Exhibit size was grouped into three clusters, small, medium, and large, as listed in *Table 17*. Significant relationships were found between exhibit size and the following variables: happiness level, excitement level, and anger level. It can be seen in *Table 19* that smaller exhibits promoted the highest happiness and excitement levels for visitors. Interestingly, medium-sized exhibits tended to have the highest anger levels. The strongest relationship is seen between exhibit size and excitement level. There were no other significant results relating exhibit size to survey responses.

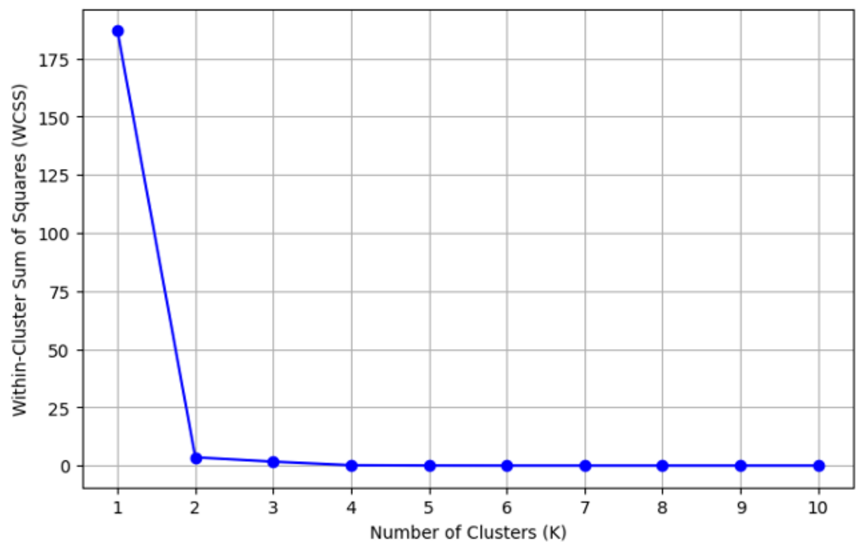

Figure 12. Elbow method for optimal clusters (measured exhibit size)

Cluster: Exhibit Size	Mean Exhibit Size (m^2)	Standard Deviation
0 (Small Exhibits)	185.01	63.85
1 (Medium Exhibits)	1251.0	0.00
2 (Large Exhibits)	7529.0	555.29

Table 17. Exhibit size levels by cluster

Cluster: Exhibit Size	Overall Experience	Likelihood to Return	Animal Welfare Rating
0 (Small Exhibits)	M = 4.67, SD = 0.57	M = 4.72, SD = 0.69	M = 4.50, SD = 0.66
1 (Medium Exhibits)	M = 4.70, SD = 0.63	M = 4.61, SD = 0.94	M = 4.39, SD = 0.84
2 (Large Exhibits)	M = 4.46, SD = 0.74	M = 4.63, SD = 0.90	M = 4.32, SD = 0.82
F-statistic	2.43535	0.334042	1.144851
p-value	0.090387	0.716457	0.320528

Table 18. ANOVA results (satisfaction variables across exhibit size clusters)

Cluster: Exhibit Size	Stress Level	Happiness Level*	Sadness Level	Excitement Level***	Anger Level**	Relaxation Level
0 (Small Exhibits)	M = 1.43, SD = 0.89	M = 4.61, SD = 0.64	M = 1.33, SD = 0.72	M = 4.29, SD = 0.79	M = 2.68, SD = 3.59	M = 4.20, SD = 0.91
1 (Medium Exhibits)	M = 1.34, SD = 0.71	M = 4.26, SD = 1.05	M = 1.65, SD = 1.27	M = 3.95, SD = 1.07	M = 3.04, SD = 2.47	M = 4.13, SD = 1.01
2 (Large Exhibits)	M = 1.25, SD = 0.59	M = 4.36, SD = 0.77	M = 1.36, SD = 0.78	M = 3.68, SD = 1.01	M = 1.19, SD = 0.53	M = 4.25, SD = 0.82
F-statistic	1.0389	3.3395*	1.3854	9.0185***	6.6075**	0.1634
p-value	0.355917	0.037616	0.252819	0.000183	0.001693	0.849360

*p < 0.05, **p < 0.01, ***p < 0.001

Table 19. ANOVA results (emotional responses across exhibit size clusters)

Cluster: Exhibit Size	Overall Zoo Design Rating	Animals' Benefit from Design Rating	Visitors' Benefit from Design Rating
0 (Small Exhibits)	M = 4.59, SD = 0.60	M = 4.30, SD = 0.86	M = 4.48, SD = 0.77
1 (Medium Exhibits)	M = 4.52, SD = 0.73	M = 4.30, SD = 0.82	M = 4.30, SD = 0.76
2 (Large Exhibits)	M = 4.44, SD = 0.67	M = 4.31, SD = 0.91	M = 4.5, SD = 0.69
F-statistic	1.061593	0.003409	0.672918
p-value	0.348013	0.996597	0.511469

Table 20. ANOVA results (perception of zoo design and benefits across exhibit size clusters)

Cluster: Exhibit Size	Exhibit Satisfaction	Size Rating	Materials Rating	Vegetation Rating	Animal Visibility Rating
0 (Small Exhibits)	M = 4.53, SD = 0.61	M = 4.27, SD = 0.90	M = 4.61, SD = 0.63	M = 4.30, SD = 0.89	M = 4.40, SD = 0.87
1 (Medium Exhibits)	M = 4.52, SD = 0.59	M = 4.30, SD = 0.88	M = 4.70, SD = 0.47	M = 4.57, SD = 0.66	M = 4.43, SD = 0.79
2 (Large Exhibits)	M = 4.63, SD = 0.68	M = 4.43, SD = 0.89	M = 4.54, SD = 0.80	M = 4.32, SD = 0.84	M = 4.62, SD = 0.79
F-statistic	0.555249	0.634511	0.499789	0.961280	1.411434
p-value	0.574888	0.531351	0.607480	0.384315	0.246420

Table 21. ANOVA results (design feature ratings across exhibit size clusters)

The percent vegetation, interior exhibit only, was also grouped into three clusters, as shown in *Table 22*. Significant relationships were found between the percent vegetation (interior) and excitement level and anger level. It can be seen in *Table 24* that exhibits with a higher percentage of vegetation promoted the highest excitement levels and lowest anger levels. Interestingly, exhibits with a medium percent vegetation (interior) tended to have much higher anger levels. The strongest relationship is seen between the percent vegetation (interior) and anger level. There were no other significant results relating the percent of vegetation inside the exhibits to survey responses.

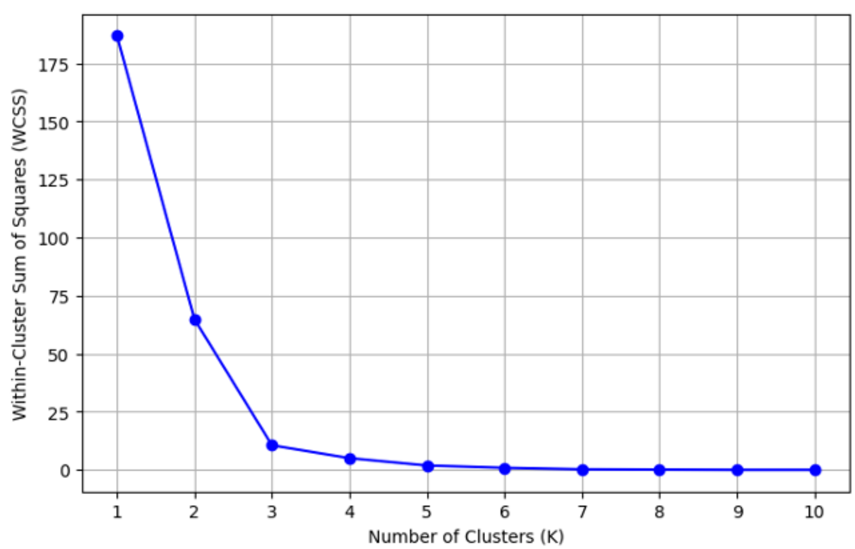

Figure 13. Elbow method for optimal clusters (% vegetation, interior exhibit only)

Cluster: % Vegetation (int)	Mean Vegetation (interior exhibit only)	Standard Deviation
0 (low % vegetation)	46%	2.54
1 (moderate % vegetation)	57.66%	2.45
2 (high % vegetation)	77.09%	0

Table 22. Exhibit % vegetation (interior exhibit only) by cluster

Cluster: % Vegetation (int)	Overall Experience	Likelihood to Return	Animal Welfare Rating
0 (low % vegetation)	M = 4.52, SD = 0.69	M = 4.64, SD = 0.79	M = 4.48 , SD = 0.72
1 (moderate % vegetation)	M =4.65 , SD = 0.59	M =4.67 , SD = 0.87	M = 4.28 , SD = 0.78
2 (high % vegetation)	M = 4.84, SD = 0.37	M =4.89 , SD = 0.45	M =4.57 , SD = 0.60
F-statistic	2.259906	0.791787	1.936537
p-value	0.107250	0.454572	0.147130

Table 23. ANOVA results (satisfaction variables across % vegetation-interior clusters)

Cluster: % Vegetation (int)	Stress Level	Happiness Level	Sadness Level	Excitement Level**	Anger Level***	Relaxation Level
0 (low % vegetation)	M = 1.33 , SD = 0.8	M = 4.49 , SD = 0.76	M = 1.31 , SD = 0.62	M = 4.04, SD = 0.91	M =1.29 , SD = 0.77	M = 4.26, SD = 0.85
1 (moderate % vegetation)	M =1.4 , SD = 0.79	M = 4.4 , SD = 0.79	M = 1.56, SD = 1.12	M = 3.84 , SD = 1.01	M = 4.04, SD = 4.29	M = 4.15, SD = 0.89
2 (high % vegetation)	M =1.36 , SD = 0.68	M = 4.73 , SD = 0.56	M = 1.15, SD = 0.50	M = 4.73, SD = 0.45	M = 1.15, SD = 0.5	M = 4.10, SD = 1.14
F-statistic	0.154310	1.404333	2.560054	6.941235**	24.207701	0.467360
p-value	0.857115	0.248150	0.080052	0.001241	0.000000	0.627396

*p < 0.05, **p < 0.01, ***p < 0.001

Table 24. ANOVA results (emotional responses across % vegetation-interior clusters)

Cluster: % Vegetation (int)	Overall Zoo Design Rating	Animals' Benefit from Design Rating	Visitors' Benefit from Design Rating
0 (low % vegetation)	M = 4.51, SD = 0.63	M = 4.37, SD = 0.8	M = 4.5, SD = 0.69
1 (moderate % vegetation)	M = 4.51, SD = 0.66	M = 4.2, SD = 0.89	M = 4.42, SD = 0.7
2 (high % vegetation)	M = 4.68, SD = 0.58	M = 4.31, SD = 1.1	M = 4.47, SD = 1.07
F-statistic	0.572058	0.775983	0.217552
p-value	0.565363	0.461751	0.804692

Table 25. ANOVA results (perception of zoo design and benefits across % vegetation-interior clusters)

Cluster: % Vegetation (int)	Exhibit Satisfaction	Size Rating	Materials Rating	Vegetation Rating	Animal Visibility Rating
0 (low % vegetation)	M = 4.56 , SD = 0.63	M = 4.3, SD = 0.91	M =4.64 , SD = 0.6	M = 4.24 , SD = 0.85	M = 4.45, SD = 0.85
1 (moderate % vegetation)	M = 4.53, SD = 0.64	M = 4.23, SD = 0.9	M = 4.5, SD = 0.75	M = 4.37, SD = 0.86	M =4.45 , SD =0.87
2 (high % vegetation)	M = 4.68 , SD = 0.58	M = 4.73 , SD = 0.65	M = 4.68, SD = 0.74	M = 4.73, SD = 0.65	M = 4.68, SD = 0.58
F-statistic	0.428702	2.392500	1.071868	2.909391	0.650658
p-value	0.652003	0.094239	0.344496	0.057021	0.522899

Table 26. ANOVA results (design feature ratings across % vegetation-interior clusters)

The percent vegetation, including the entire viewing area, was also grouped into three clusters, as shown in *Table 27*. Significant relationships were found between the percent vegetation (entire viewing area) and excitement level, anger level, and exhibit size rating. It can be seen in *Table 29* that exhibits with a *lower* percentage of vegetation in the viewing area promoted the highest excitement levels but the highest anger levels. Exhibits with a medium percent vegetation (entire viewing area) tended to have the highest exhibit size ratings. The strongest relationship is seen between the percent vegetation (entire viewing area) and anger level. There were no other significant results relating the percent vegetation in the entire viewing area to survey responses.

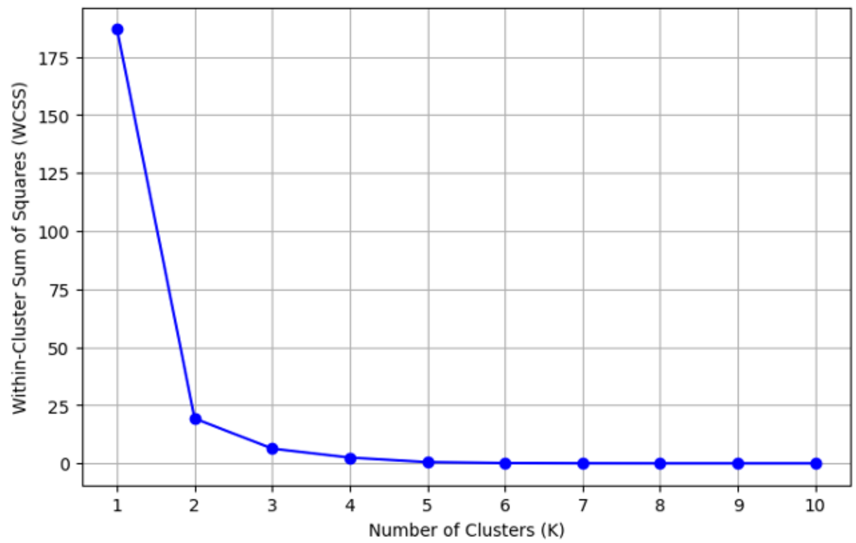

Figure 14. Elbow method for optimal clusters (% vegetation, entire viewing area)

Cluster: % Vegetation (ext)	Mean Vegetation (entire viewing area)	Standard Deviation
0 (low % vegetation)	14.53%	8.31
1 (moderate % vegetation)	57.63%	0.00
2 (high % vegetation)	89.00%	5.52

Table 27. Exhibit % vegetation (entire viewing area) by cluster

Cluster: % Vegetation (ext)	Overall Experience	Likelihood to Return	Animal Welfare Rating
0 (low % vegetation)	M = 4.63, SD = 0.59	M = 4.68, SD = 0.73	M = 4.47, SD = 0.67
1 (moderate % vegetation)	M = 4.38, SD = 0.86	M = 4.57, SD = 0.87	M = 4.42, SD = 0.67
2 (high % vegetation)	M = 4.63, SD = 0.61	M = 4.7, SD = 0.847	M = 4.36, SD = 0.81
F-statistic	1.437534	0.225370	0.429350
p-value	0.240168	0.798441	0.651583

Table 28. ANOVA results (satisfaction variables across exhibit size clusters)

Cluster: % Vegetation (ext)	Stress Level	Happiness Level	Sadness Level	Excitement Level*	Anger Level**	Relaxation Level
0 (low % vegetation)	M = 1.45, SD = 1.02	M = 4.58, SD = 0.66	M = 1.37, SD = 0.76	M = 4.19, SD = 0.82	M = 3.03, SD = 3.9	M = 4.23, SD = 0.86
1 (moderate % vegetation)	M = 1.19, SD = 0.51	M = 4.38, SD = 0.8	M = 1.19, SD = 0.51	M = 3.52, SD = 1.12	M = 1.19, SD = 0.60	M = 4.61, SD = 0.66
2 (high % vegetation)	M = 1.32, SD = 0.67	M = 4.41, SD = 0.81	M = 1.44, SD = 0.94	M = 4.03, SD = 0.97	M = 1.69, SD = 1.58	M = 4.09, SD = 0.95
F-statistic	1.137897	1.262910	0.764451	4.372844*	6.366536**	2.958358
p-value	0.322737	0.285270	0.467062	0.013952	0.002121	0.054378

*p < 0.05, **p < 0.01, ***p < 0.001

Table 29. ANOVA results (emotional responses across exhibit size clusters)

Cluster: % Vegetation (ext)	Overall Zoo Design Rating	Animals' Benefit from Design Rating	Visitors' Benefit from Design Rating
0 (low % vegetation)	M = 4.57, SD = 0.60	M = 4.30, SD = 0.79	M = 4.48, SD = 0.68
1 (moderate % vegetation)	M =4.38, SD = 0.74	M = 4.66, SD = 0.65	M = 4.61, SD = 0.59
2 (high % vegetation)	M = 4.53, SD = 0.64	M = 4.22, SD = 0.96	M = 4.41, SD = 0.82
F-statistic	0.748848	2.195667	0.660606
p-value	0.474347	0.114192	0.517759

Table 30. ANOVA results (perception of zoo design and benefits across exhibit size clusters)

Cluster: % Vegetation (ext)	Exhibit Satisfaction	Size Rating*	Materials Rating	Vegetation Rating	Animal Visibility Rating
0 (low % vegetation)	M = 4.5, SD = 0.61	M =4.15, SD =0.92	M = 4.59, SD = 0.6	M = 4.19, SD = 0.9	M = 4.32, SD = 0.91
1 (moderate % vegetation)	M = 4.8, SD = 0.47	M = 4.6, SD = 0.73	M = 4.76, SD = 0.53	M = 4.47, SD = 0.67	M = 4.71, SD = 0.56
2 (high % vegetation)	M = 4.55, SD = 0.66	M = 4.40, SD =0.87	M = 4.55, SD = 0.76	M =4.44, SD = 0.81	M = 4.55, SD = 0.79
F-statistic	2.743868	3.36281*	0.751857	2.079465	2.565229
p-value	0.066954	0.036780	0.472933	0.127925	0.079650

*p < 0.05, **p < 0.01, ***p < 0.001

Table 31. ANOVA results (design feature ratings across exhibit size clusters)

The number of individual animals in each exhibit was also grouped into three clusters, as shown in *Table 32*. Significant relationships were found between the number of individuals and excitement level, anger level, and ratings for the animals' benefit from design. It can be seen in

Table 34 that exhibits with a moderate number of individuals promoted the highest excitement levels and exhibits with smaller numbers of individuals promoted the highest anger levels. Exhibits with a large number of individuals tended to have the highest ratings for whether the animals were benefitting from the design of their space. The strongest relationship is seen between the number of individual animals and anger level. There were no other significant results relating the number of individual animals to survey responses.

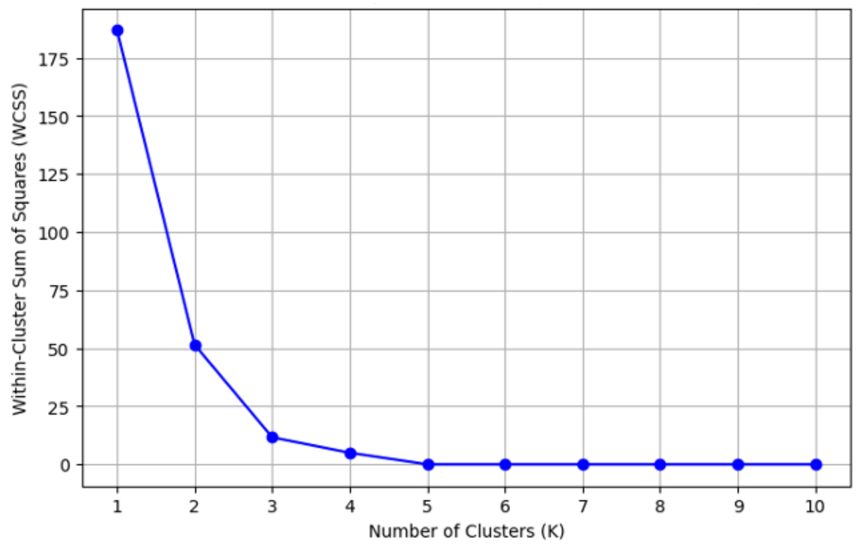

Figure 15. Elbow method for optimal clusters (# individual animals)

Cluster: # Individuals	Mean # of Individual Animals	Standard Deviation
0 (low)	2.21	0.41
1 (moderate)	4.35	0.48
2 (high)	7.00	0.00

Table 32. # of individual animals by cluster

Cluster: # Individuals	Overall Experience	Likelihood to Return	Animal Welfare Rating
0 (low)	M = 4.58, SD = 0.65	M = 4.66, SD = 0.78	M = 4.40, SD = 0.76
1 (moderate)	M = 4.71 , SD = 0.49	M = 4.74, SD = 0.8	M = 4.45, SD = 0.72
2 (high)	M = 4.38 , SD = 0.86	M = 4.57, SD = 0.87	M = 4.42, SD = 0.67
F-statistic	2.155109	0.413640	0.107961
p-value	0.118807	0.661852	0.897719

Table 33. ANOVA results (satisfaction variables across exhibit size clusters)

Cluster: # Individuals	Stress Level	Happiness Level	Sadness Level	Excitement Level*	Anger Level***	Relaxation Level
0 (low)	M = 1.39, SD = 0.84	M = 4.42, SD = 0.82	M = 1.43, SD = 0.89	M = 4.09, SD = 0.87	M = 2.95, SD = 3.60	M = 4.14, SD = 0.9
1 (moderate)	M = 1.37, SD = 0.76	M = 4.62, SD = 0.58	M = 1.35, SD = 0.80	M = 4.15, SD = 0.96	M = 1.27, SD = 0.73	M = 4.2, SD = 0.92
2 (high)	M = 1.19, SD = 0.51	M = 4.38, SD = 0.8	M = 1.19, SD = 0.51	M = 3.52, SD = 1.12	M = 1.19, SD = 0.6	M = 4.61, SD = 0.66
F-statistic	0.581484	1.527840	0.839108	3.817476*	8.612541***	2.552908
p-value	0.560092	0.219744	0.433743	0.023745	0.000266	0.080610

*p < 0.05, **p < 0.01, ***p < 0.001

Table 34. ANOVA results (emotional responses across exhibit size clusters)

Cluster: # Individuals	Overall Zoo Design Rating	Animals' Benefit from Design Rating*	Visitors' Benefit from Design Rating
0 (low)	M = 4.56, SD = 0.63	M = 4.35, SD = 0.81	M = 4.43, SD = 0.71
1 (moderate)	M = 4.54, SD = 0.62	M = 4.10, SD = 0.97	M = 4.47, SD = 0.83
2 (high)	M = 4.38, SD = 0.74	M = 4.66, SD = 0.65	M = 4.61, SD = 0.58
F-statistic	0.693438	3.725862*	0.512983
p-value	0.501156	0.025929	0.599561

*p < 0.05, **p < 0.01, ***p < 0.001

Table 35. ANOVA results (perception of zoo design and benefits across exhibit size clusters)

Cluster: # Individuals	Exhibit Satisfaction	Size Rating	Materials Rating	Vegetation Rating	Animal Visibility Rating
0 (low)	M = 4.53, SD = 0.63	M = 4.28, SD = 0.91	M = 4.63, SD = 0.57	M = 4.34, SD = 0.85	M = 4.36, SD = 0.91
1 (moderate)	M = 4.52, SD = 0.65	M = 4.27, SD = 0.9	M = 4.47, SD = 0.85	M = 4.27, SD = 0.88	M = 4.59, SD = 0.74
2 (high)	M = 4.85, SD = 0.47	M = 4.7, SD = 0.73	M = 4.76, SD = 0.53	M = 4.47, SD = 0.67	M = 4.71, SD = 0.56
F-statistic	2.552852	1.732063	1.781715	0.463565	2.409093
p-value	0.080615	0.179791	0.171241	0.629770	0.092727

Table 36. ANOVA results (design feature ratings across exhibit size clusters)

CHAPTER 5. DISCUSSION AND CONCLUSIONS

This study aims to provide insights into the relationships between zoo exhibit design, visitor demographics, and zoo visitor experience and impressions of exhibit design. The following chapter discusses the implications of significant test results presented in *Chapter 4*. While many of the research hypotheses were supported, some unexpected findings emerged. Results showed that species, animal affinity, and various exhibit design aspects significantly impacted visitor experience, especially their emotional states. Overall, larger exhibits with more active animals and moderate to high levels of vegetation provided the highest satisfaction for visitors, but individual design aspects had varying impacts on visitor experience, emotions, and ratings of exhibit design. Further analysis highlighted the importance of designing for the desired outcomes.

5.1 Impacts of Visitor Demographics on Results

The study captured a diverse sample of zoo visitors, contributing to research on human interactions with natural and synthetic zoo environments. The participant pool included a slightly higher proportion of female respondents than reported by the Association of Zoos and Aquariums (AZA). Nearly half of the participants were aged 18–34, with more than half holding an associate's degree or higher. Many respondents traveled long distances to the surveyed zoos and were experienced zoo-goers.

Correlation analyses supported some research hypotheses. A slight negative correlation between visitor age and excitement levels suggests that older visitors may be less stimulated by exhibit design elements, indicating a need for designs that engage all age groups. I did not ask about signage in the survey, leaving room for future research on the impacts of signage. Incorporating varied educational content could enhance experiences across demographics. Interactive designs, for example, one that encourages children to climb like a monkey or attempt to jump as far as a tiger, can be educational and fun for younger visitors. On the other end of the spectrum, older visitors could benefit more from informational signage that is more detailed; for example, a species' conservation status, the impacts of different sustainable practices, or a particular historical fact about the zoo.

A negative correlation was also found between frequent zoo visits (including visits to multiple zoos) and self-reported sadness. This suggests that increased exposure to zoos and their conservation efforts fosters a more nuanced understanding of their roles beyond entertainment. Zoos can enhance this effect by providing more educational signage and interactive learning opportunities, including volunteer or staff-led discussions to deepen visitor engagement. Future studies could examine the effectiveness of informational signage and its impact on visitor perceptions.

ANOVA tests revealed gender-based differences in excitement levels, with female participants reporting higher excitement. Education level also influenced perceptions of exhibit benefits, with more educated visitors perceiving greater benefits, reinforcing the importance of widespread zoo education initiatives. These factors cannot be controlled by zoos, but they demonstrate that visitors do have varying impressions and reactions to zoo design.

Unexpectedly, visitor affinity for exhibit species played a larger role in shaping experiences and emotions than demographic differences. A strong positive correlation was observed between species likability and overall experience ratings. Visitors who favored certain animals reported higher happiness, excitement, relaxation, and exhibit satisfaction. These findings suggest that zoos should consider species' appeal while adhering to Species Survival Plan (SSP) guidelines to optimize visitor experience. Further analysis comparing specific housed species is presented in Section 5.4.

5.2 Impacts of Exhibit Design on Results

Affirming the hypotheses for impacts of exhibit design, correlation tests provided insights into the relationships between exhibit design and visitor experience. It was hypothesized that larger exhibits with denser vegetation and more transparent barriers would enhance visitor experience and emotions. However, a negative correlation was found between exhibit size and excitement levels, with smaller exhibits eliciting higher excitement. Cluster analysis further confirmed that smaller exhibits were associated with higher excitement and happiness ratings, likely due to closer proximity to animals. Considering this, zoos should design exhibits that provide ample space for the animal inhabitants but are laid out in a way that allows visitors to be closer to the animals. This will take creative design solutions, like naturalistic corridor exhibits that wind throughout the park, rather than enclosing exhibits in large, wide-open rings where animals may often be distant or hard to view. However, it is important to consider how these designs could negatively impact animal welfare. Many species require open spaces for optimal health and welfare, and to reflect their natural environments, and close proximity to people could increase stress or stereotypic behaviors.

Conversely, vegetation density positively correlated with overall visitor experience and exhibit design ratings. Cluster analysis reinforced this finding, revealing that higher vegetation levels within exhibits promoted greater excitement and reduced anger. Interestingly, moderate vegetation levels in viewing areas were correlated with the highest exhibit size ratings, suggesting that an optimal balance of greenery may enhance spatial perception. Zoos should consider finding a balance between enough vegetation in their design to improve visitor experience and emotional states, but not so much vegetation that sight lines are impeded in viewing exhibit spaces.

Barrier materials also influenced visitors' emotions and exhibit satisfaction. ANOVA results showed that exhibits with transparent barriers (glass, wire, or netting) generated higher excitement ratings than those with opaque materials like wooden fencing. Glass barriers were also associated with higher exhibit size and vegetation ratings, whereas wire or netting barriers received the lowest satisfaction scores. Wooden fencing, while rated highly for exhibit satisfaction, scored lower for perceived size and vegetation. These findings suggest that zoos should tailor barrier materials to desired visitor experiences, balancing immersion with naturalistic aesthetics. The inclusion of various materials, including wood and glass, is important for improving visitor impressions of zoos, and visibility should be highly considered in choosing the materials for the primary barriers between visitors and the animals.

5.3 Impacts of Exhibit Species and Animal Activity on Results

Several significant relationships emerged between species type, animal activity, and visitor experience. Smaller carnivorous species (e.g., otters, lynx, wolves) generated higher excitement ratings than larger ungulates (e.g., elk, zebra, bongos). This could be attributed to the smaller species' greater activity levels, as the larger ungulate species often spend more time grazing or resting. It could also be related to differences in exhibit design, as the ungulates were housed in consistently larger enclosures. Zoos should potentially prioritize smaller or more active species in their 'main attractions,' however, it is good to have a diverse collection of species and natural behaviors to satisfy visitors with varying animal affinities.

Exhibits featuring elk, wolves, or otters received higher ratings for animal benefits, exhibit satisfaction, and perceived exhibit size. While otters and wolves were among the most exciting species, these ratings were also influenced by exhibit characteristics such as barrier type, vegetation, and size. Notably, the elk and wolf exhibits were the largest studied, likely affecting size perceptions. Conversely, the otter exhibits were the smallest included in the study but the smaller animals were housed proportionally. This suggests that perceived *appropriateness* of space may impact visitor satisfaction more than actual exhibit size. Zoos must consider the size of the animals being housed in designing their living spaces to find the balance between large, impressive natural exhibits and smaller, more exciting, interactive exhibits.

Animal activity significantly influenced visitor emotions and exhibit ratings. ANOVA tests showed that active animals correlated with higher overall experience, likelihood of return, happiness, and excitement ratings. Additionally, active animals improved exhibit satisfaction and visibility scores, highlighting the importance of animal engagement in visitor perceptions. It is clear that animal activity plays a large part in zoo visitor satisfaction, and previous studies have highlighted that animal activity is heavily influenced by environmental factors. Zoos should prioritize designing dynamic exhibit environments with interactive features and routine enrichment to encourage stimulating natural behaviors, in turn enhancing both animal welfare and visitor experience.

5.4 Limitations

One limitation of this study is the inclusion of only three zoos, all located in Michigan's lower peninsula. A larger-scale analysis would enhance the generalizability to zoos worldwide. However, findings may still apply to similar exhibits featuring the same species, particularly those with multiple representations across the studied zoos. Expanding the research to include more diverse exhibits and animal classes beyond mammals would provide a broader understanding of visitor-exhibit interactions.

Surveys were conducted using convenience sampling during non-peak periods to minimize external stimuli, which may have introduced demographic biases. Despite efforts to capture a diverse range of visitors, certain patterns emerged. Single visitors with young children were often reluctant to participate, potentially limiting the generalizability of demographic influences. Additionally, when approached in mixed-gender groups, women were more likely to engage in the survey than men.

5.5 Conclusion

This study provides valuable insights into the relationships between zoo visitor demographics, exhibit design, animal activity, and visitor experience and impressions of zoo design. Findings emphasize the importance of exhibit scale, vegetation density, barrier transparency, and species engagement in shaping visitor experiences. Additionally, demographic factors such as age, gender, and education level influence perceptions, though species affinity plays a dominant role in visitor satisfaction. To optimize visitor experiences while promoting conservation awareness, zoos should design exhibits that cater to diverse age groups by integrating multi-level educational content. They should enhance educational outreach through signage and staff interactions and foster animal activity through enrichment programs to boost visitor satisfaction and animal well-being. In exhibit design, it is important to balance exhibit size and proximity to animals to maintain engagement and utilize transparent or immersive barrier materials to enhance visibility.

Similar studies could be applied to zoos outside of Michigan or even outside the US to better evaluate zoo design in a broader context. Analysis of other types of exhibits should be considered as well, including aviaries or indoor reptile housing, as this study focused only on outdoor mammal exhibits. Future research should explore broader geographic contexts, diverse exhibit types, and the long-term impact of educational interventions on visitor perceptions. Understanding these factors can aid zoos in refining their strategies to enhance both visitor experience and conservation messaging.

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APPENDIX I. IRB APPROVAL LETTER

MICHIGAN STATE
UNIVERSITY

Initial Study APPROVAL

Revised Common Rule

May 10, 2024

To: Fatemeh Saeidi-Rizi

Re: **MSU Study ID:** STUDY00010401

Office of Regulatory Affairs
Human Research Protection Program

4000 Collins Road
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IRB: Social Science / Behavioral / Education Institutional Review Board

Principal Investigator: Fatemeh Saeidi-Rizi

Category: Expedited 7

Submission: Initial Study STUDY00010401

Submission Approval Date: 5/10/2024

Effective Date: 5/10/2024

Study Expiration Date: None; however modification and closure submissions are required (see below).

Title: Impacts of Natural Zoo Enclosure Design on Visitor Experience & Zoo Perceptions

This submission has been approved by the Michigan State University (MSU) SIRB. The submission was reviewed by the Institutional Review Board (IRB) through the Non-Committee

Figure 16. IRB Approval Letter

Figure 16 (cont'd)

Review procedure. The IRB has found that this study protects the rights and welfare of human subjects and meets the requirements of MSU's Federal Wide Assurance (FWA00004556) and the federal regulations for the protection of human subjects in research (e.g., 2018 45 CFR 46, 21 CFR 50, 56, other applicable regulations).

How to Access Final Documents

To access the study's final materials, including those approved by the IRB such as consent forms, recruitment materials, and the approved protocol, if applicable, please log into the Click™ Research Compliance System, open the study's workspace, and view the "Documents" tab. To obtain consent form(s) stamped with the IRB watermark, select the "Final" PDF version of your consent form(s) as applicable in the "Documents" tab. Please note that the consent form(s) stamped with the IRB watermark must typically be used.

Expiration of IRB Approval: The IRB approval for this study does not have an expiration date. Therefore, continuing review submissions to extend an approval period for this study are not required. **Modification and closure submissions are still required (see below).**

Modifications: Any proposed change or modification with certain limited exceptions discussed below must be reviewed and approved by the IRB prior to implementation of the change. Please submit a Modification request to have the changes reviewed.

New Funding: If new external funding is obtained to support this study, a Modification request must be submitted for IRB review and approval before new funds can be spent on human research activities, as the new funding source may have additional or different requirements.

Immediate Change to Eliminate a Hazard: When an immediate change in a research protocol is necessary to eliminate a hazard to subjects, the proposed change need not be reviewed by the IRB prior to its implementation. In such situations, however, investigators must report the change in protocol to the IRB immediately thereafter.

Reportable Events: Certain events require reporting to the IRB. These include:

- Potential unanticipated problems that may involve risks to subjects or others
- Potential non-compliance
- Subject complaints

Figure 16 (cont'd)

- Protocol deviations or violations
- Unapproved change in protocol to eliminate a hazard to subjects
- Premature suspension or termination of research
- Audit or inspection by a federal or state agency
- New potential conflict of interest of a study team member
- Written reports of study monitors
- Emergency use of investigational drugs or devices
- Any activities or circumstances that affect the rights and welfare of research subjects
- Any information that could increase the risk to subjects

Please report new information through the study's workspace and contact the IRB office with any urgent events. Please visit the Human Research Protection Program (HRPP) website to obtain more information, including reporting timelines.

Personnel Changes: Key study personnel must be listed on the MSU IRB application for expedited and full board studies and any changes to key study personnel must to be submitted as modifications. Although only key study personnel need to be listed on a non-exempt application, all other individuals engaged in human subject research activities must receive and maintain current human subject training, must disclose conflict of interest, and are subject to MSU HRPP requirements. It is the responsibility of the Principal Investigator (PI) to maintain oversight over all study personnel and to assure and to maintain appropriate tracking that these requirements are met (e.g. documentation of training completion, conflict of interest). When non-MSU personnel are engaged in human research, there are additional requirements. See HRPP Manual Section 4-10, Designation as Key Project Personnel on Non-Exempt IRB Projects for more information.

Prisoner Research: If a human subject involved in ongoing research becomes a prisoner during the course of the study and the relevant research proposal was not reviewed and approved by the IRB in accordance with the requirements for research involving prisoners under subpart C of 45 CFR part 46, the investigator must promptly notify the IRB.

Figure 16 (cont'd)

Site Visits: The MSU HRPP Compliance office conducts post approval site visits for certain IRB approved studies. If the study is selected for a site visit, you will be contacted by the HRPP Compliance office to schedule the site visit.

For Studies that Involve Consent, Parental Permission, or Assent Form(s):

> **Use of IRB Approved Form:** Investigators must use the form(s) approved by the IRB and must typically use the form with the IRB watermark.
>
> **Copy Provided to Subjects:** A copy of the form(s) must be provided to the individual signing the form. In some instances, that individual must be provided with a copy of the signed form (e.g. studies following ICH-GCP E6 requirements). Assent forms should be provided as required by the IRB.

Record Retention: All records relating to the research must be appropriately managed and retained. This includes records under the investigator's control, such as the informed consent document. Investigators must retain copies of signed forms or oral consent records (e.g., logs). Investigators must retain all pages of the form, not just the signature page. Investigators may not attempt to de-identify the form; it must be retained with all original information. The PI must maintain these records for a minimum of three years after the IRB has closed the research and a longer retention period may be required by law, contract, funding agency, university requirement or other requirements for certain studies, such as those that are sponsored or FDA regulated research. See HRPP Manual Section 4-7-A, Record-keeping for Investigators, for more information.

Closure: If the research activities no longer involve human subjects, please submit a Continuing Review request, through which study closure may be requested. Closure indicates that research activities with human subjects are no longer ongoing, have stopped, and are complete. Human research activities are complete when investigators are no longer obtaining information or biospecimens about a living person through interaction or intervention with the individual, obtaining identifiable private information or identifiable biospecimens about a living person, and/or using, studying, analyzing, or generating identifiable private information or identifiable biospecimens about a living person.

Figure 16 (cont'd)

For More Information: See the HRPP Manual (available at hrpp.msu.edu).

Contact Information: If we can be of further assistance or if you have questions, please contact us at 517-355-2180 or via email at IRB@msu.edu. Please visit hrpp.msu.edu to access the HRPP Manual, templates, etc.

Expedited Category. Please see the appropriate research category below for the full regulatory text.

Expedited 1. Clinical studies of drugs and medical devices only when condition (a) or (b) is met.

(a) Research on drugs for which an investigational new drug application (21 CFR Part 312) is not required. (Note: Research on marketed drugs that significantly increases the risks or decreases the acceptability of the risks associated with the use of the product is not eligible for expedited review.)

(b) Research on medical devices for which (i) an investigational device exemption application (21 CFR Part 812) is not required; or (ii) the medical device is cleared/approved for marketing and the medical device is being used in accordance with its cleared/approved labeling.

Expedited 2. Collection of blood samples by finger stick, heel stick, ear stick, or venipuncture as follows:

(a) from healthy, non-pregnant adults who weigh at least 110 pounds. For these subjects, the amounts drawn may not exceed 550 ml in an 8 week period and collection may not occur more frequently than 2 times per week; or

(b) from other adults and children, considering the age, weight, and health of the subjects, the collection procedure, the amount of blood to be collected, and the frequency with which it will be collected. For these subjects, the amount drawn may not exceed the lesser of 50 ml or 3 ml per kg in an 8 week period and collection may not occur more frequently than 2 times per week.

Expedited 3. Prospective collection of biological specimens for research purposes by noninvasive means.

Examples: (a) hair and nail clippings in a non-disfiguring manner; (b) deciduous teeth at time of exfoliation or if routine patient care indicates a need for extraction; (c) permanent teeth if routine patient care indicates a need for extraction; (d) excreta and external secretions (including sweat);

Figure 16 (cont'd)

(e) uncannulated saliva collected either in an unstimulated fashion or stimulated by chewing gum-base or wax or by applying a dilute citric solution to the tongue; (f) placenta removed at delivery; (g) amniotic fluid obtained at the time of rupture of the membrane prior to or during labor; (h) supra- and sub-gingival dental plaque and calculus, provided the collection procedure is not more invasive than routine prophylactic scaling of the teeth and the process is accomplished in accordance with accepted prophylactic techniques; (i) mucosal and skin cells collected by buccal scraping or swab, skin swab, or mouth washings; (j) sputum collected after saline mist nebulization.

Expedited 4. Collection of data through noninvasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing. (Studies intended to evaluate the safety and effectiveness of the medical device are not generally eligible for expedited review, including studies of cleared medical devices for new indications.)

Examples: (a) physical sensors that are applied either to the surface of the body or at a distance and do not involve input of significant amounts of energy into the subject or an invasion of the subject's privacy; (b) weighing or testing sensory acuity; (c) magnetic resonance imaging; (d) electrocardiography, electroencephalography, thermography, detection of naturally occurring radioactivity, electroretinography, ultrasound, diagnostic infrared imaging, dopplerblood flow, and echocardiography; (e) moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual.

Expedited 5. Research involving materials (data, documents, records, or specimens) that have been collected, or will be collected solely for non-research purposes (such as medical treatment or diagnosis). (NOTE: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b)(4). This listing refers only to research that is not exempt.)

Figure 16 (cont'd)

Expedited 6. Collection of data from voice, video, digital, or image recordings made for research purposes.

Expedited 7. Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies. (NOTE: Some research in this category may be exempt from the HHS regulations for the protection of human subjects. 45 CFR 46.101(b)(2) and (b)(3). This listing refers only to research that is not exempt.)

Expedited 8. Continuing review of research previously approved by the convened IRB as follows:

(a) where (i) the research is permanently closed to the enrollment of new subjects; (ii) all subjects have completed all research-related interventions; and (iii) the research remains active only for long-term follow-up of subjects; or

(b) where no subjects have been enrolled and no additional risks have been identified; or

(c) where the remaining research activities are limited to data analysis.

Expedited 9. Continuing review of research, not conducted under an investigational new drug application or investigational device exemption where categories two (2) through eight (8) do not apply but the IRB has determined and documented at a convened meeting that the research involves no greater than minimal risk and no additional risks have been identified.

APPENDIX II. SURVEY

Insert Research Participant Information and Consent Form

What is your age?

- ◉ 13-17
- ◉ 18-34
- ◉ 35-54
- ◉ 55-74
- ◉ >75 Years
- ◉ I prefer not to say

What is your identified gender?

- ◉ Male
- ◉ Female
- ◉ Non-Binary
- ◉ I prefer not to say

What is the highest level of education you have completed?

- ◉ High School or GED
- ◉ Trade/Technical/Vocational Training
- ◉ Associate or Bachelor's Degree
- ◉ Master's or Professional Degree
- ◉ Doctorate or PhD
- ◉ I prefer not to say

How far did you travel to visit this zoo today?

- ◉ <5 Miles
- ◉ 5-15 Miles
- ◉ 16-30 Miles
- ◉ 31-45 Miles
- ◉ >45 Miles

How many other zoos have you been to before?

◉This is my first time in a zoo

◉1 or 2 other zoos

◉3-5 other zoos

◉6-10 other zoos

◉>10 other zoos

How often do you visit this zoo?

◉This is my first time at this zoo

◉Once per year

◉A few times per year

◉Once per month

◉A few times per month

◉A few times per week

How would you rate your **overall experience** at the zoo today?

(On a scale of 1-5, with 5 being the best)

Overall Experience ☆☆☆☆☆

How likely are you to *return* to this zoo? (On a scale of 1-5, with 5 being the best)

Please select your choice ☆☆☆☆☆

At which **exhibit** are you currently taking this survey? Please list the *animal* (ex: Elk, Lynx, River Otter)

____

How much do you *like* the **animal(s)** in this exhibit? (On a scale of 1-5, with 5 being the best)

Please select your choice ☆☆☆☆☆

Which of the following **activities** are the animal(s) engaging in? (*Select all that apply*)

◉ Sleeping or Resting

◉ Eating or Foraging for Food

◉ Socializing or Vocalizing

◉ Walking or Running

◉ Climbing or Swimming

◉ The Animal(s) Aren't Visible

According to the AZA Animal Welfare Committee, "**Animal Welfare** refers to an animal's collective **physical**, **mental**, and **emotional states** over a period of time, and is measured on a continuum from *good* to *poor*. An animal typically experiences **good welfare** when healthy, comfortable, well-nourished, safe, able to develop and express species-typical relationships, behaviors, and cognitive abilities, and *not* suffering from unpleasant states such as pain, fear, or distress. Because physical, mental, and emotional states may be dependent on one another and can vary from day to day, it is important to consider these states in combination with one another over time to provide an assessment of an animal's overall welfare status."

Based on what you can see today, how would you rate the Welfare of the animal(s) in the exhibit you are currently visiting?

◉ Poor

◉ Below Average

◉ Average

◉ Above Average

◉ Great

How would you rate this exhibit **overall**? (On a scale of 1-5, with 5 being the best)

Overall Exhibit ☆☆☆☆☆

How would you rate the **type of materials** used in the *exterior* of this exhibit? Ex: windows, fencing, walls, etc (On a scale of 1-5, with 5 being the best)

Type of Materials ☆☆☆☆☆

How would you rate the **amount of vegetation** used in this exhibit? (On a scale of 1-5, with 5 being the best)

Amount of Vegetation ☆☆☆☆☆

How would you rate the **visibility of the animal(s)** in this exhibit? (On a scale of 1-5, with 5 being the best)

Animal Visibility ☆☆☆☆☆

How would you rate the **size of this exhibit** for the animal(s) it houses? (On a scale of 1-5, with 5 being the best)

Exhibit Size ☆☆☆☆☆

Please select whether you *agree* with the following statements:

This exhibit makes me feel Stressed.

◉ Definitely Disagree

◉ Slightly Disagree

◉ Neutral

◉ Slightly Agree

◉ Definitely Agree

This exhibit makes me feel Happy.

◉ Definitely Disagree

◉ Slightly Disagree

◉ Neutral

◉ Slightly Agree

◉ Definitely Agree

This exhibit makes me feel Sad.

- ◉ Definitely Disagree
- ◉ Slightly Disagree
- ◉ Neutral
- ◉ Slightly Agree
- ◉ Definitely Agree

This exhibit makes me feel Excited.

- ◉ Definitely Disagree
- ◉ Slightly Disagree
- ◉ Neutral
- ◉ Slightly Agree
- ◉ Definitely Agree

This exhibit makes me feel Angry.

- ◉ Definitely Disagree
- ◉ Slightly Disagree
- ◉ Neutral
- ◉ Slightly Agree
- ◉ Definitely Agree

This exhibit makes me feel Relaxed.

- ◉ Definitely Disagree
- ◉ Slightly Disagree
- ◉ Neutral
- ◉ Slightly Agree
- ◉ Definitely Agree

Please select whether you *agree* with the following statements:

The animal(s) in this exhibit are benefitting from the design of their space.

◉ Definitely Disagree

◉ Slightly Disagree

◉ Neutral

◉ Slightly Agree

◉ Definitely Agree

Zoo visitors, including myself, are benefitting from the design of this exhibit.

◉ Definitely Disagree

◉ Slightly Disagree

◉ Neutral

◉ Slightly Agree

◉ Definitely Agree

Thinking about enclosure design specifically, how would you rate your **overall impression** of the zoo today? (On a scale of 1-5, with 5 being the best)

Please select your choice ☆☆☆☆☆

Optional: Is there any additional feedback about the exhibit design you would like to provide?

____