

MITIGATING FEELINGS OF DISPLACEMENT:
EXPLORING ZOOLOGICAL DESIGN PRINCIPLES IN
CAPTIVITY & BEYOND

by
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This thesis explores the evolving role of zoos in the Anthropocene, focusing on the integration of ethical design, animal welfare, and conservation within economic sustainability frameworks. It examines how zoos, facing urban expansion and climate change, transition from traditional exhibition spaces to dynamic conservation hubs. The study employs a philosophical and conceptual approach, reviewing literature across landscape architecture, animal psychology, and conservation science, and analyzing case studies on innovative enclosure designs that mimic natural habitats and foster natural behaviors. Additionally, the thesis discusses the economic viability of immersive, naturalistic landscapes that enhance visitor engagement and education, supporting conservation and financial sustainability. It argues that modern zoos must evolve beyond mere exhibition to become proactive agents of biodiversity preservation, facing ethical, ecological, and economic challenges. Through this evolution, intentional zoological design can alleviate feelings of displacement in captive individuals and wild populations. This work contributes to the discourse on global wildlife conservation, proposing sustainable and ethically responsible zoological design practices.

Dedication

This thesis is dedicated to the memory of my grandfather, whose love for the natural world inspired my own passion for environmental science and conservation. His wisdom, guidance, and deep appreciation for nature have left an indelible mark on my life. Thank you, Pappy, for teaching me to see the beauty and importance of our natural world. Your legacy continues to inspire me every day.

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Introduction:

In the heart of urban sprawl and amidst the expanding footprints of human habitation, zoological institutions represent an intersection where the balance between international conservation efforts and animal welfare is most palpable. As bastions of biodiversity conservation, modern zoos are tasked by modern ecological pressures with preserving species & ensuring their inhabitants' physical and psychological well-being, while simultaneously battling against the encroaching void of the Anthropocene. In the face of the climate crisis, the necessity for zoological parks and aquariums to morph into conservation centers has never been more crucial. “Zoos have been transformed since their roots as exotic menageries, designed to showcase wealth and status” (Bostock, 1993), and “many zoos are now conservation centers with extensive expertise and skills which address many Sustainable Development Goals and Global Biodiversity Framework targets (CBD Convention on Biological Diversity, 2022; DEFRA, 2018; UNEP and CBD, 2011; United Nations, 2015)” (Spooner). This dual mandate—preservation & welfare—has ushered in a new era of zoological design, where the focus shifts from mere exhibition to the creation of environments that mitigate the feelings of displacement experienced by captive animals. As zoological parks deepen their commitment to conservation, they must also navigate the complex waters of financial sustainability. This delicate balance involves developing engaging, educational experiences that not only attract visitors but also generate the revenue necessary to support expansive conservation efforts and ethical animal care. So, in expanding our ideas of what a zoo exhibit can look like, we may find benefits beyond the ecological & economic.

What is Displacement?

“Displacement” – also known as habitat loss, degradation, or fragmentation– refers to the multifaceted phenomenon wherein animals experience a loss or significant alteration of their natural habitat due to human activities, leading to various psychological and physical effects (National Wildlife Federation). This displacement is not just physical—stemming from the removal or degradation of an animal's natural environment—but also encompasses a broader spectrum of behavioral and emotional impacts that captive environments may induce. Mary Akeley, expeditioner and American Natural History Museum diorama designer states, “An animal cannot be isolated, even conceptually, from the particular environment to which it has become adopted during eons of geologic time without a serious misunderstanding of its true nature” (Akeley, 1936). Jon Coe, the world-renowned zoo architect, explored Akeley’s advice by stating, “It is *this* vision of animals and their natural landscapes, inseparable, which has led most directly to the development of a particular type of animal display commonly referred to as “landscape immersion (Jones, et al 1976)” (Coe, 1).

Displacement encapsulates the challenges animals face when their living conditions are either fundamentally changed from their wild state to captivity *or* when human-induced habitat fragmentation leads to disruption of natural behaviors in a native landscape. Captive environments often lack the complexity, space, and environmental features of their native habitats; fragmented environments often lack the resources and security necessary for natural behaviors and ecological stability. Displacement, therefore, involves both the spatial and existential reorientation of animals from living in the wild, with the freedom to roam, hunt, and engage in instinctual social structures, to a state of confinement within human-designed enclosures or habitat fragments. This transition can lead to heightened stress, abnormal behaviors

(often termed "zoochosis"), and a general decline in the well-being of zoo inhabitants or affected wild populations. In her paper "Zoochosis: A short review of stereotypical behavior of captive animals", Roheela Yaseem states, "These behaviors can limit animals from intermixing with their natural environment in a species-characteristic manner"(Yasmeen, 9). The ethical and zoological design challenge lies in alleviating these negative impacts through the construction of enclosures that not only physically resemble natural habitats but also provide opportunities for natural behaviors, thereby addressing the psychological aspects of displacement and improving the overall quality of life for captive animals.



Figure 1: Historical Illustration of London Zoo, 1835 (New York Times).

Recognizing A Paradigm Shift:

The significance of the shift toward captivity-induced displacement mitigation cannot be overstated. Historical methods of zoo enclosure design, often limited by spatial and resource constraints, have been criticized for failing to address the complex needs of animals, leading to heightened stress and abnormal behaviors among zoo inhabitants. A study on chronic captivity stress in wild animals in *Conservation Physiology*, a medical journal, states,

The [captivity] stress response consists of the suite of hormonal and physiological reactions to help an animal survive potentially harmful stimuli. The adrenomedullary

response results in increased heart rate and muscle tone (among other effects); elevated glucocorticoid (GC) hormones help to direct resources toward immediate survival. While these responses are adaptive, overexposure to stress can cause physiological problems, such as weight loss, changes to the immune system, and decreased reproductive capacity (Fischer and Romero).

The imperative for evolution in zoo design emerges clearly from a historical context. While older enclosures prioritized human amusement over animal welfare, modern zoological practices strive to bridge the divide between entertainment and ethics. “By the 1980s, American zoos began recognizing the interconnections between humans and nature and represented that through exhibit messaging” (Uddin 2015). This transformation reflects a deeper societal shift towards recognizing and rectifying the impacts of human activities on wildlife. Kathi McQueen states in her article, “Social Shifts in Animal Interpretation”, “Humans are no longer satisfied to see an animal “caged” for our enjoyment. Society is shifting towards seeing animals in a natural setting (or as close to natural as possible). We want to develop relationships with the animals we meet and know them on a personal level” (McQueen, 32). In the era of the Anthropocene, zoos are poised to serve as crucial interfaces where public engagement, species preservation, and ethical responsibility converge, revealing the complex interplay between maintaining biodiversity and fulfilling the demands of a capitalist society. Many of the first formal Western zoos, such as the London Zoo, began as expensive entertainment-focused, members-only institutions (Rothfels, 2002). Now, many of these institutions are owned *privately* but funded *publicly*. The modern zoo is a place dedicated to public education and wildlife conservation, yet it is restricted by a capitalist model. Critics of zoos often hear that wild animals in managed care generally have longer lifespans than their counterparts in the wild. This is due to a lack of natural predators in

captivity, and animals in well-managed zoos typically receive health care that can surpass that available to many humans. This dichotomy underscores a critical gap in our understanding and application of zoological design principles that not only reflects an ethical stance towards animal welfare but also embodies the conservation ethos & capitalist drive of zoos in the 21st century.

The Anthropocene, a term popularized by Crutzen and others, refers to an epoch marked by human dominance over nature, presenting unparalleled challenges and responsibilities. In this context, zoos transform into arks of hope and hubs of biodiversity conservation, navigating the delicate balance between educational endeavors, ethical considerations, and the intrinsic needs of their inhabitants.



Figure 2: The Ark of Space, Shigeru Komatsuzaki, 1968

Finally, as urban and suburban areas continue to expand, integrating zoological design principles into broader environmental management strategies offers a critical approach to mitigating wildlife displacement. This thesis will examine how methods used within zoos to minimize animal stress and emulate natural habitats can be adapted to manage and enhance biodiversity in human-altered landscapes. By extending these design concepts beyond the

confines of zoos, we can contribute to the development of habitats that support both animal welfare and ecological diversity.

This thesis ventures into the widely critiqued territories of habitat simulation techniques and animal-centric design principles within zoological parks. By dissecting the impacts of displacement on captive animals, it seeks to illuminate pathways through which thoughtful design can enhance animal well-being and promote equitable species representation. In doing so, this study not only addresses a significant lacuna in the existing scholarly discourse on animal welfare and habitat design but also posits a framework for future zoological designs that aligns with broader conservation imperatives, wild population recovery efforts, and the mitigation of climatic change. By bridging the gap between theoretical principles and practical applications, this thesis aims to contribute to the evolution of zoos from mere collections of exotic fauna to centers of conservation excellence and animal welfare advocacy.

Methods:

Central to this inquiry are the ethical dimensions of zoological parks. At the advent of the Anthropocene, the traditional paradigms of zoo design and animal captivity were called into question, prompting a reevaluation of the moral obligations toward non-human beings under human care. Michael J. Renner, Professor of Biology at the University of California Berkeley, states, “A recent revision to [zoo & aquarium] accreditation standards in 2018, however, supersedes this model [previously focused only on *animal health*] in favor of a new goal – that a zoo or aquarium demonstrate it has achieved *animal welfare*. Not only must animals be healthy, but they should also display behavior typical of their species. Climbers must climb, diggers must dig, and runners must run” (The Conversation). This thesis argues for a design ethos that prioritizes the *welfare* of zoo inhabitants, leveraging insights from fields as diverse as landscape

ecology, animal psychology, and conservation science. Innovative enclosure designs that provide animals with environments simulating their natural habitats, as well as opportunities for natural behaviors, are examined as vital components in mitigating the feelings of displacement.

Theoretical Framework:

This thesis utilizes a philosophical and conceptual approach to explore the intersection of ethical zoo design and animal welfare. Drawing upon an extensive review of existing literature in landscape architecture, animal psychology, and conservation science, this study examines the principles and outcomes of contemporary zoo design on conservation efforts and economic viability. The discourse analysis will focus on identifying and discussing key themes and arguments presented in the literature, particularly those that relate to ethical considerations and the psychological impact of design on zoo animals.

Case Studies and Anecdotal Evidence:

To enrich the theoretical analysis, select case studies of zoological parks that have implemented innovative and ethically-driven habitat designs will be discussed. These cases will be drawn from secondary sources, including published studies, reports, and credible media. Anecdotes from these sources will be used to illustrate successful practices and the philosophical underpinnings behind them, providing real-world examples of how theory is applied in practice.

Synthesis of Philosophical and Design Principles:

By synthesizing findings from the literature and case studies, this thesis will construct a framework for understanding how modern zoos can balance ethical mandates with practical design solutions. The discussion will critically engage with the concepts of displacement,

naturalistic enclosures, and the role of zoos in the Anthropocene, proposing a set of design principles that align with both ethics and welfare.

As we embark on this exploration, it is imperative to recognize that the stakes extend beyond the confines of zoological parks. In the face of accelerating habitat destruction and climate change, the lessons gleaned from the design of captive environments hold profound implications for wildlife conservation at large. Additionally, the financial impacts of adopting immersive landscapes must be considered, as these environments not only require significant initial investment but also present opportunities for enhanced visitor engagement and revenue generation, ultimately influencing the economic sustainability of zoological institutions. This thesis hopes to stand at the nexus of landscape architecture, animal psychology, and conservation science, discussing the future of zoological parks and the precious lives they harbor.

Literature Review:

This literature review aims to scrutinize and synthesize the array of scholarly perspectives concerning the design and function of modern zoological parks within the context of conservation and animal welfare. As we navigate the diverse discourse, this section will explore pivotal concepts such as *displacement*, which refers to the myriad ways in which animals experience loss or alteration of their natural habitats due to human activities, leading to physical and psychological impacts. Another key term, *zooscape ecology*, describes the application of landscape ecology principles to the design of zoo habitats, enhancing both the ecological functionality and the experiential quality of these spaces. Furthermore, the review will delve into *naturalistic enclosures*, which are designed to mimic the complexity and richness of wild environments, providing animals opportunities for expressing natural behaviors and thus, mitigating the effects of captivity. By examining these concepts through the lens of recent

studies and theories, the literature review aims to frame the current state of zoological design, identify gaps in knowledge, and propose pathways toward more ethical and sustainable practices in the management and evolution of zoos. This exploration aims to create a deeper understanding of how modern zoos can align more closely with the dual mandates of animal welfare and conservation.

Post-Zoo Design: Alternative Futures in the Anthropocene:

In the shadow of climatic change, Rua Alshaheen's "Post-Zoo Design: Alternative Futures in the Anthropocene" offers an imperative pivot in addressing the profound implications of displacement on captive wildlife within zoological institutions. Amidst the burgeoning human footprint and urban expansion, these institutions embody a critical junction where the mitigation of displacement's effects on captive animals underscores an evolving paradigm in zoological design. Alshaheen navigates through the ethical and design complexities of creating habitats that not only physically echo the wild but also foster natural behaviors, aiming to alleviate the multifaceted strains of displacement. This encompasses not merely the spatial transposition from wilderness to confinement but also a profound existential reorientation impacting animals' psychological and physical well-being. By leveraging a future-oriented lens, underpinned by the Manoa School's alternative futures, the dissertation underscores the urgency of reimagining zoo habitats as spaces that transcend traditional exhibition, morphing into sanctuaries that confront and counteract the adverse effects of displacement. Through a holistic integration of architecture, environmental science, and animal welfare studies, this work hopes to illuminate pathways toward enclosures that are not mere physical replications of natural habitats but are imbued with the complexities and richness of wild environments, addressing the intricate challenges posed by the impacts of the Anthropocene. This resonates with the current discourse on habitat simulation

techniques and animal-centric design principles, affirming the necessity for zoological parks to evolve beyond being mere collections of fauna, thus aligning zoological practices with the imperative conservation ethos of habitat preservation, species recovery, and sustainability in an epoch of human dominance.

Zoo Inverso:

Building on the theoretical foundation laid by Alshaheen, Marissa Engelbrecht's "Zoo Inverso" further explores the role of landscape architecture in enhancing the zoo experience for both animals and visitors. Engelbrecht argues for a design approach that synthesizes ecological sustainability with visitor engagement through the creation of "hybridized interactive experiences." These experiences are designed to integrate nature, animals, and humans within detailed enclosure designs, demonstrating how landscape design can effectively combine ecology and aesthetics. Engelbrecht states, "The outcome will demonstrate how landscape design can combine ecology and aesthetics to create a hybridized interactive experience with nature, animals, and humans in a detailed enclosure design" (Engelbrecht, 3). This approach not only promotes biodiversity within urban landscapes but also enhances the visitor experience, thereby contributing to the zoo's economic sustainability and aligning with the ethical imperatives highlighted by Alshaheen. Engelbrecht explores the principles of landscape immersion through Seattle-based architecture firm, Jones & Jones' viewing guidelines which state:

1. Ensure that the animals are seen as only a part of the surrounding landscape that they co-occupy with the viewer
2. Provide selected views only into the exhibit
3. Augment the sense of anticipation by sequential staging of approach views before the animals are actually seen

4. Screen out the cross-viewing of other people and exhibits
5. Eliminate views of animals from outside zoo and from parking and entry areas

Despite these stringent guidelines, some landscape immersion exhibits still face critique of space limitation, lack of complete effect, and performative design. Englebrecht urges the reader to recall “the critical importance of landscape immersion as a technique for zoo design is that it acknowledges the importance and value of natural systems” (Zoo Inverso, 109).

Zooscape Ecology (Concept):

Daniel Bisgrove's seminal work on zooscape ecology marks a pivotal shift in understanding zoos not merely as collections of diverse species but as dynamic ecosystems that contribute to conservation and education. This concept advocates for the integration of landscape ecology principles into zoo design, emphasizing the role of zoos as active conservation and educational hubs that support biodiversity and promote sustainable coexistence between humans and wildlife. Bisgrove's work underscores the vital role of zoos in the current era, emphasizing their transition from mere animal exhibitions to active conservation, community, and educational hubs. “Zoos are mirrors of society, including collective views toward not only animals but also groups of people (Bisgrove 2022). This study aligns with the literature's growing consensus on the necessity of integrating landscape ecology principles into zoo design. He states, "Zoos must promote humanity's continued coexistence with other species. A landscape view is essential to achieving this goal" (Bisgrove). He advocates for zoos to serve as models for sustainable landscapes, mirroring the complexity and functionality of natural habitats.

This approach not only supports biodiversity within urban settings but also enhances the welfare of zoo inhabitants by providing more naturalistic and enriching environments. "By carefully applying landscape ecology principles in planning and design within zoos, we can

create sustainable zooscapes that not only display wild animals but also contribute to landscape sustainability" (Bisgrove). The concept of 'zooscapes' introduced by Bisgrove, wherein zoos are envisioned as ecological sanctuaries that foster human-wildlife interactions, directly addresses the challenges of displacement by advocating for designs that closely replicate the animals' natural environments, thus mitigating the psychological and physical impacts of captivity. This idea has the potential to expand its impacts beyond the bounds of one enclosure or the zooscape. Building on the foundational principles of zooscape ecology, we turn to the practical implementation of these ideas in the form of naturalistic, immersive enclosures.

Naturalistic Enclosures (In-Practice):

A study by Fàbregas, Guillén-Salazar, and Garcés-Narro critically examines the effectiveness of naturalistic enclosures in zoos, providing empirical evidence supporting their benefits over traditional enclosures in terms of animal welfare. This study directly addresses a gap in zoological research. "The provision of a suitable environment with the resources that will allow the animals to satisfy their main biological needs in naturalistic enclosures has never been systematically explored; instead, it has been assumed" (Fàbregas, Guillén-Salazar, and Garcés-Narro). Their research, which assessed a wide range of enclosures across Spanish zoos, found that naturalistic designs significantly enhance the suitability of environments for captive animals, contributing to better psychological and physical health outcomes. The team states, "[m]ost naturalistic enclosures (77.8%) provided suitable environments for their inhabitants. Non-naturalistic ones also had suitable environments, but in a lower percentage (39.7%)" (Fàbregas, Guillén-Salazar, and Garcés-Narro). This underscores the importance of designing zoo habitats that not only mimic the physical aspects of natural environments but also support the complex

behavioral needs of animals, directly confronting the issue of displacement by creating spaces that allow for a semblance of natural living conditions within the confines of captivity.

Integration:

Integrating insights from "Zooscape Ecology: A Conceptual Analysis of Zoos and Landscape Ecology" by Daniel Bisgrove, "Do Naturalistic Enclosures Provide Suitable Environments for Zoo Animals?" by María C. Fàbregas, Federico Guillén-Salazar, and Carlos Garcés-Narro, and Marissa Engelbrecht's "Zoo Inverso" with Rua Alshaheen's dissertation offers a multifaceted understanding of the current zoological discourse. "Zoo Inverso" particularly enriches this discourse by advocating for a design approach that synthesizes ecological sustainability with visitor engagement through the creation of "hybridized interactive experiences," demonstrating how landscape design can effectively combine ecology and aesthetics within zoo enclosures. This concept aligns with and extends the ecological and ethical frameworks discussed by Bisgrove and Alshaheen, emphasizing not just the physical, but also the experiential quality of zoo habitats that engage both humans and animals in meaningful interactions.

In synthesizing these works with Alshaheen's dissertation, a coherent literature review emerges that highlights a paradigm shift in zoological design toward addressing the ethical and practical challenges posed by the Anthropocene. In the face of environmental crisis, zoos must evolve beyond mere exhibition spaces to become active agents of conservation and education (Alshaheen 2019). The collective insights from these studies advocate for a reimagined approach to zoo habitats, where the focus extends beyond mere physical resemblance to wild environments. Instead, there's an emphasis on creating dynamic ecosystems that support natural behaviors and enhance the overall well-being of captive wildlife. This body of work contributes

to the broader conservation discourse by illustrating the potential of zoos not only as centers of biodiversity preservation and educational outreach but also as ethical spaces that prioritize the welfare of their inhabitants, thereby offering critical insights into the alleviation of displacement effects on captive animals in the Anthropocene era.

Navigating the Intersections of Conservation and Capitalism in Modern Zoos:

The conceptual underpinnings of modern zoo design, which stress the importance of creating habitats that support both the physical and psychological needs of animals, set the stage for an essential and practical discourse on the economic aspects of zoo management. As we transition from a literature review that emphasizes ethically and ecologically centered design principles to a detailed examination of the financial frameworks that support these ideals, it becomes imperative to explore how these innovative designs can be realized within the economic constraints and opportunities that contemporary zoos face. This discussion will delve into the practicalities of funding, maintaining, and evolving zoological parks in ways that align with global conservation ambitions, ensuring that the ideals of habitat simulation and animal well-being are not only visionary but also viably implemented in the fiscal realities of the 21st century.

Modern zoological parks, as key players in the global conservation landscape, operate at the complex intersection of ethical wildlife conservation and economic viability. The dual mandate to be financially sustainable while advancing conservation efforts forces zoos to reconcile their role as educational and biodiversity preservation entities with their need to operate as financially solvent institutions. Mooney, Conde, Healy, & Buckley state, “The global zoo and aquarium community fulfills several objectives, including conservation, education, research, and entertainment. These multiple roles can place competing demands on the

composition of zoo collections as public preferences do not always align with conservation priorities” (2). Zoos are increasingly expected to create immersive, naturalistic habitats that provide more than just containment for animals; they are tasked with creating environments that encourage natural behaviors, support psychological well-being, and educate the public about conservation issues. However, the development of such habitats is often more costly than traditional enclosures, involving sophisticated design, larger land areas, specialized materials, and ongoing maintenance to mimic the dynamic nature of wild ecosystems.

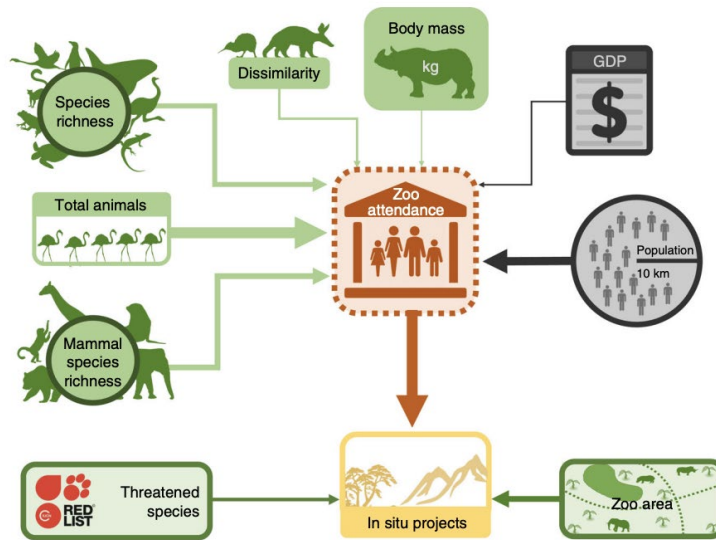


Figure 3: Total effects of institutional variables and socio-economic variables on visitor attendance and in situ contributions (Mooney)

The economic model of zoos relies heavily on visitor revenue, which can fluctuate based on economic conditions, competition from other entertainment options, and public perceptions of the institution's ethical standards. “Zoo area and the proportion of threatened species are also positively correlated with in situ conservation projects, albeit these effects are weaker than attendance. Collection composition variables (total no. of animals, total species richness,

mammal species richness, compositional dissimilarity and species body mass) are more important in determining attendance than socio-economic variables (population density and gross domestic product [GDP])” (Mooney et al, 2). The challenge is to create compelling, immersive experiences that not only draw visitors but also promote conservation education and support, thus enhancing the zoo's financial health and its conservation mission. The question of whether ethical conservation practices can be profitable centers on the potential for immersive landscapes to increase visitor engagement and satisfaction. Enhanced visitor experiences can lead to increased ticket sales, memberships, repeat visitation, and positive word-of-mouth, which are crucial revenue streams for zoos. Despite the high initial costs, there are several ways in which immersive and ethically designed habitats can be economically viable.

First, these habitats can enhance the visitor experience which in turn can drive revenue through ticket sales and secondary spending on site, such as at gift shops and restaurants. Furthermore, zoos that are known for their high standards of animal welfare and innovative habitat design can enhance their reputation and brand, attracting more donations, higher-profile partnerships, and potentially larger grants from conservation-focused organizations. Moreover, immersive landscapes can serve educational purposes, aligning with zoo missions to educate the public about biodiversity and conservation issues. This educational role can be leveraged to obtain funding from educational and governmental bodies interested in promoting scientific literacy and environmental awareness.

The Balance Between Conservation Ethics and Profitability:

The challenge lies in balancing these economic benefits with the costs and ensuring that conservation and animal welfare are not compromised for profitability. Zoos must strategize to use their resources efficiently, possibly prioritizing which species and habitats to focus on based

on both conservation needs and potential for visitor interest. One potential solution is the adoption of mixed-use spaces within the zoo. These spaces can be used for multiple purposes—such as small-scale events, educational programs, and conservation fundraisers—which can help subsidize the cost of maintaining high-quality animal habitats. Community building spaces such as these can support both the ecological and economic missions of a zoological institution. Additionally, partnerships can provide financial support and innovative technologies for habitat design and conservation efforts; however, in the quest for financial sustainability, modern zoological parks often face profound ethical dilemmas, particularly when it comes to corporate sponsorship.

Conflicts of Interest:

While mixed-use spaces within zoos can serve multiple purposes, the role of corporate funding in these efforts presents a significant paradox. On one hand, partnerships with institutions and corporations can provide essential financial support and innovative technologies for habitat design and conservation efforts, enabling zoos to enhance their conservation work and educational outreach. On the other, these same corporations may be engaged in activities that compromise the natural environments they purport to help preserve. For example, The Woodland Park Zoo in Seattle is famously known to house “the very first naturalistic gorilla enclosure on the planet” (Gorilla’s Land, 2). The large enclosure houses nine gorillas in total, comprised of two distinct social groups. Listed as Endangered by the IUCN, gorillas face multiple forms of displacement in the wild. From habitat destruction to disruptive ecotourism, these great apes struggle with psychological stress in their native habitat. The enclosure at the Woodland Park Zoo has had great success keeping troupes of gorillas, successfully breeding them, and actively supporting primate research; however, the enclosure is largely funded by Boeing, –the Seattle-

based aviation manufacturing corporation. Boeing produced 386 million metric tons of greenhouse gas emissions in 2022, alone (Boeing, 4). The company's logo is even within eyeshot of animal viewing. This juxtaposition and other similar examples at zoos across the world create an ethical conundrum: can zoos truly advocate for conservation while accepting funds from entities that may be contributing to environmental degradation?

In an Ideal World:

The ideal zoological institution seeks to support robust conservation efforts that are untainted by the conflicting interests of its benefactors. However, in a capitalist system, this ideal is challenging to achieve. The reality is that many corporations view sponsorship of conservation initiatives as a part of their corporate social responsibility programs, which can sometimes serve more to improve their public image rather than signify a genuine commitment to environmental stewardship. This is known as greenwashing (de Freitas Netto, 2020). This –easily viewed as corrupt– relationship between zoos and corporate sponsors is emblematic of the broader challenges faced in a capitalist system where economic interests often overshadow environmental and ethical considerations. By rigorously assessing and auditing the sources of their funding and actively influencing corporate practices, zoos can relieve the ethical dilemmas they face. This approach not only enhances their credibility as conservation leaders but also ensures that their efforts in habitat preservation and species recovery are not compromised by the actions of their benefactors. In this way, zoos can strive to become bastions of *true* sustainability, advocating for and embodying practices that genuinely contribute to the preservation of biodiversity.

Looking Forward: Economics of the Zoo in the Anthropocene

As we project into the future, the role of zoos is likely to continue to evolve in response to changing ecological and economic landscapes. In an era marked by rapid environmental change and biodiversity loss, zoos can serve as beacons of hope, preserving species that are at risk or endangered in the wild. The economic models of zoos will need to adapt to this role, possibly focusing more on conservation and less on entertainment, altering the traditional revenue models.

While the economic profitability of immersive, naturalistic zoo landscapes is not guaranteed, a strategic approach that combines ethical conservation practices with savvy economic planning could create a sustainable model for modern zoos. Uplifted by a societal shift in animal welfare, this model would not only support the well-being of captive animals but also contribute to global conservation efforts., thereby aligning the operations of zoos with the broader ecological and ethical imperatives of our time.

Principles of Landscape Immersion and Naturalistic Enclosures:

Zooscape ecology represents an innovative approach in zoo design, where principles of landscape ecology are applied to developing zoo habitats. This concept transcends traditional zoo design by creating environments that are not only visually and functionally akin to natural habitats but also supportive of the ecological and behavioral needs of the animals. Here, we delve deeper into the application of landscape design principles in zoos and explore how these can support conservation efforts and animal welfare simultaneously.

Landscape immersion aims to fulfill the biological needs of animals by replicating natural forms as closely as possible. Advocates of this approach argue that the most effective way to

address both the known and unknown requirements of an animal is to create a highly accurate reproduction of their natural habitat (Braverman 2012). Landscape immersion involves designing zoo habitats that seamlessly blend with the natural environment, creating a more authentic and engaging experience for visitors while minimizing stress and promoting natural behaviors among the animals. John Bierlein, Manager of Planning and Interpretive Exhibits, at Woodland Park Zoo stated, “The underlying goal of this approach is to stimulate psychological responses in humans that deepen the appreciation of animals, their habitats, and the interdependence of life” (ZooLex). The shift in design ethics in zoological design was foreseen in 1801 by a French Count Lancepede when he stated that the ideal zoological park “is not an accumulation of buildings or bird cages or cages , but instead constitutes a true scenery” (Van der Bergh, 1962). This design philosophy extends beyond mere visual mimicry to include immersive soundscapes, specific vegetative species, and substrates that mirror the animals' native landscapes. During its redesign in the late 1970s, Seattle’s Woodland Park Zoo, under the direction of zoo architect David Hancocks, pioneered a new approach to zoo exhibits. This marked a significant shift from the stark, concrete and barred exhibits typical of the mid-twentieth century (Hancocks 2001). Immersive, naturalistic enclosures take this concept further by focusing on the specific needs of each species, providing them with environments that not only look natural but also function ecologically as their wild counterparts would. This includes features like water sources, hiding places, and varied terrain, offering animals choices in how they use their space and interact with their environment. Cynthia Vernon of Monterey Bay Aquarium once stated, “Exhibits are the outward manifestation of an institution’s soul.” Thus, allowing the zoogoer the most naturalistic view of captive wildlife curated by that particular zoo, a visitor can truly unlock the ethos of that

specific institution. Jon Coe, iconic zoo architect, stated, “Much like a theater, the zoo-goer become the spectators who participate in the theatrical act of the animals” (Coe, 2012).

Landscape Ecology in Zoos:

Landscape ecology primarily deals with how landscape structure affects the abundance, distribution, and interaction of organisms within an ecosystem (Wu 2013). The application of landscape ecology principles to zoo design transcends traditional approaches by incorporating strategies that enhance both the welfare of captive animals, the educational experience of visitors, and the implications beyond the boundaries of enclosure. These principles not only replicate the physical structure of natural habitats but also their ecological functions, ensuring that zoo environments serve as models of sustainable and educational conservation practices. “In 1975, leading zoo architect Jon Coe explained that a landscape immersion exhibit places the animal in the context of nature, rather than the context of architecture, and that it makes the visitor feel part of nature rather than an outside observer of it” (Braverman 2012). The burgeoning field of ecology not only catalyzed the development of landscape ecology in the 1970s but also influenced landscape immersion. The importance of ecosystems became starkly apparent, leading to a swift departure from former architectural styles that overlooked these benefits. In their place, new designs emerged that incorporated significant natural features (Bisgrove). Applying these principles to zoo design involves several key aspects:

Habitat Connectivity:

Designing zoo landscapes that mimic the connectivity found in natural habitats can significantly improve animal well-being. In the wild, habitat connectivity allows for the movement and migration of species, facilitating genetic exchange and ecological processes. In

zoos, this principle can be manifested through the design of landscapes that allow animals to experience a semblance of movement and migration within safe and controlled limits. Several zoos are now exploring the concept of using habitat corridors as part of their exhibit spaces. The Philadelphia Zoo, constrained by its central urban location and limited size, has innovated to enhance its exhibits through Zoo360. This network of maze-like trails allows various animal species to traverse the zoo, encountering new sights, smells, and experiences. Since the launch of the initial trails in 2011, the network has expanded significantly: lemurs and monkeys can explore a treetop trail and tower, great apes have access to a climbing path, big cats can traverse an overhead passageway, and gorillas can use an elevated walkway (Philadelphia Zoo 2016). This could involve interconnected habitat zones that animals can move between, or the use of landscaped corridors that link different parts of the zoo, mimicking the animal's natural movement patterns. Such designs not only encourage natural behavior but also prevent the boredom and stress associated with static enclosures. For many species, the capability to traverse longer distances than those offered by traditional exhibits is not just beneficial but medically necessary. This is particularly true for captive elephants, which can suffer from severe foot infections if they do not engage in sufficient walking, coupled with inadequate foot care (Mehren 2003). To address this issue, several zoos have redesigned elephant exhibits to include pathways that encourage more walking. For instance, when the National Zoo unveiled its renovated elephant exhibit in 2013, it featured a one-third-mile uphill walking trail, enabling the elephants to exercise and explore different areas of the zoo (Associated Press 2013). The introduction of corridors can significantly alter the behavior and possibilities for many species. By considering the social and ecological connections among individual animals and species, zoos could further enhance the role of these structures in their exhibits.

Scale and Complexity:

Natural habitats are complex and vary greatly in scale, offering animals a range of microhabitats. Zooscape ecology aims to replicate this complexity by designing enclosures that provide various microhabitats and environmental features (like water bodies, varied vegetation, rocks, and terrain changes) that animals can use according to their instincts and needs. Minor heterogeneity is critically important in the context of zoo exhibits, which are generally much smaller than an animal's natural range (Bisgrove 2022). This habitat variety enriches captive animal life and viewer experience. Another intriguing aspect of zoo design is the use of multispecies exhibits. In their natural habitats, animals can easily distance themselves to find secluded areas or unique food sources. However, this mobility is more restricted in the confined spaces of zoo exhibits. To address this, zoos implement species-specific barriers. Similar to how a backyard bird feeder might be designed to cater exclusively to songbirds rather than squirrels, zoos design food containers that are accessible only to intended species. Likewise, barriers are constructed to be navigable only by smaller or more agile species, ensuring, for example, that gazelles have spaces inaccessible to giraffes (Bisgrove 2022). Consequently, the distribution of animal species within a zoo exhibit often appears as distinct, small patches rather than the expansive gradients found in nature.

Ecological Functionality:

Zoos have the potential to be living laboratories for ecological education and conservation. By integrating native plant species and designing habitats that can support local wildlife, zoos can extend their conservation impact beyond their boundaries. This ecological functionality can be enhanced by

native species garden areas dedicated to native flora that provide food and habitat for local wildlife, promoting biodiversity conservation within the urban matrix. Additionally, the use of naturalistic water bodies that not only serve as habitat but also play a role in sustainable water management, such as rain gardens and wetlands that filter stormwater runoff.

Sensory and Environmental Enrichment:

Environments can be tailored to stimulate the natural sensory experiences of animals, such as through the inclusion of natural sounds, varied lighting conditions reflecting natural cycles, and the presence of diverse materials that animals can interact with. This sensory enrichment helps in reducing stress and promoting psychological well-being among zoo inhabitants. Additionally, a multisensory landscape is attractive to visitors of zoological parks. If zoogoers can learn, engage in meaningful discussions, and form an aesthetic appreciation for animals and their habitats during their visit, then perhaps we are moving forward. As Baba Dioum said in 1968, "In the end, we will conserve only what we love."

Challenges and Opportunities in Implementing Zooscape Ecology:

Implementing these principles comes with a set of challenges and opportunities. Urban zoos often face space and financial constraints, which can limit the extent to which these principles can be applied. Creative solutions such as vertical designs, shared habitats, and multi-use spaces can help overcome these limitations. Each species has unique environmental and social needs, making it essential to tailor habitat designs accordingly. This requires in-depth research and possibly collaboration with biologists and ecologists to ensure that designs are both scientifically sound and practical. Zooscape designs offer rich opportunities for visitor education and interaction. Viewing areas that allow visitors to observe natural behaviors without disturbing

the animals can enhance educational outcomes and encourage empathy and conservation support among the public.

Integrating sustainability into zoo operations through the use of renewable energy sources, water recycling systems, and sustainable materials in construction can further align zoos with conservation goals.

Future Directions:

As we look to the future, zooscape ecology could evolve into a more holistic practice that not only encompasses the needs of captive animals but also addresses broader ecological and conservation challenges. Zoos could serve as nodes in larger conservation networks, participating in rewilding efforts, habitat restoration, and species reintroduction programs. In essence, the expansion of zooscape ecology within the framework of modern zoos offers a promising avenue toward redefining the roles of zoos in conservation and education. By adopting landscape ecological principles, zoos can create more meaningful and sustainable engagements with the natural world, fostering a deeper public understanding of biodiversity and the urgent need for its preservation.

Case Study 1: Woodland Park Zoo, Seattle, Washington (92 acres)



Figure 4: Woodland Park Zoo Map

Focus: Landscape Immersion Exhibits

Woodland Park Zoo, located in Seattle, Washington, has long been a leader in zoo design innovation. Established in 1899, the zoo spans over 92 acres and is home to more than 1,000 animals representing 300 species. Woodland Park Zoo is renowned for its implementation of

landscape immersion, a design philosophy that aims to create exhibits that allow animals to live in settings that mimic their natural habitats as closely as possible.

Design Philosophy

The landscape immersion approach was pioneered at Woodland Park Zoo in the late 1970s under the guidance of zoo architect David Hancocks. This design philosophy is centered around the idea of viewing animals not as specimens in a cage, but as inhabitants of complex ecosystems. The goal is to enhance the well-being of the animals and the educational experience of visitors by blurring the lines between the natural world and man-made enclosures.

Specific Exhibits:

- Northern Trail: Reflects the ecosystems of Alaska's tundra and taiga, providing a habitat for species like grizzly bears, wolves, and bald eagles. The exhibit is designed to offer expansive spaces that change with the seasons, replicating the animals' natural surroundings and cycles.
- Tropical Rain Forest: This exhibit creates a lush, humid environment typical of tropical rainforests, hosting a diverse range of species from jaguars to tropical birds. The multi-layered canopy and dense vegetation not only provide naturalistic shelter and privacy for the animals but also create immersive viewing experiences for visitors.
- Temperate Forest: Simulates the local ecosystems of the Pacific Northwest, featuring species that are native to the area, such as the northern spotted owl. This exhibit emphasizes conservation issues relevant to the local environment, thereby fostering a strong connection between the zoo's educational messages and the community's ecological context.

Conservation Impact

Woodland Park Zoo actively participates in global conservation efforts, including species recovery programs, habitat restoration projects, and international wildlife conservation initiatives. The zoo's design facilitates natural behaviors and breeding, contributing to the success of these programs. For example, the zoo has been involved in the conservation of tree kangaroos through its Tree Kangaroo Conservation Program, which works directly with indigenous communities in Papua New Guinea to protect biodiversity.

Educational Outreach

The zoo's immersive exhibits are designed to educate visitors about the importance of conservation while providing engaging and interactive experiences. Educational signage, guided tours, and digital apps enhance the learning experience, offering in-depth information about the animals' natural behaviors, threats to their survival, and ways visitors can contribute to conservation efforts. Programs like ZooCorps, a teen volunteer program, allow young people to engage deeply with conservation topics and gain hands-on experience.

Visitor Experience

Woodland Park Zoo's use of landscape immersion has transformed the visitor experience by offering more naturalistic views and engaging encounters with wildlife. This approach not only increases visitor satisfaction but also enhances the educational impact, as guests leave with a better understanding of ecological systems and the importance of conservation.

Case Study 2: Singapore Zoo, Singapore (69 acres)



Figure 5: Singapore Zoo Map

Focus: Open-Concept Design and Barrier-Free Habitats

Singapore Zoo, also known as Mandai Zoo, is internationally acclaimed for its open-concept and innovative design that challenges traditional zoo barriers. Spanning 69 acres, it houses over 2,800 animals from over 300 species, many of which roam freely in naturalistic habitats. This approach not only enhances the welfare of the animals but also significantly improves the educational and interactive experience for visitors.

Design Philosophy

The foundational principle of Singapore Zoo's design is the "open zoo" concept. Initiated at its opening in 1973, this design strategy minimizes visible barriers between visitors and animals, using natural features such as streams, rock walls, and vegetation to create enclosures. This philosophy aims to respect the physical and psychological needs of animals while providing a safe and immersive experience for visitors.

Specific Exhibits

- **Fragile Forest:** A biodome that mimics a rainforest ecosystem, allowing visitors to walk through a habitat shared with free-flying birds, lemurs, and sloths. This exhibit emphasizes the delicate balance of rainforest ecosystems and the interdependencies among species.
- **Great Rift Valley of Ethiopia:** An exhibit that showcases a complex savannah ecosystem complete with a troop of Hamadryas baboons, Nubian ibexes, and rock hyraxes. The design uses natural barriers and elevations to provide a seamless viewing experience that educates visitors about the ecological and cultural significance of the Great Rift Valley.
- **Frozen Tundra:** Home to polar bears, raccoon dogs, and wolverines, this exhibit uses chilled pools and air-conditioned viewing areas to replicate the cold environments of the Arctic, demonstrating the zoo's commitment to meeting the specific environmental needs of its inhabitants.

Conservation Impact

Singapore Zoo is deeply committed to conservation research and education, with numerous initiatives designed to support global biodiversity. It participates in breeding programs

for critically endangered species and engages in wildlife rescue and rehabilitation efforts. The zoo's Wildlife Healthcare and Research Centre, opened in 2006, is a testament to its dedication to animal health and conservation science.

Educational Outreach

The zoo's approach to education is interactive and immersive, utilizing animal shows, feeding sessions, and keeper talks to engage visitors. These activities are designed to teach about animal behavior, ecological relationships, and conservation challenges. Singapore Zoo also offers a "Wild Discoverer Tour" that provides behind-the-scenes insights into zoo operations and conservation efforts, further enriching the educational experience.

Visitor Experience

The open concept and thoughtful exhibit design ensure that visitors to Singapore Zoo can observe animals behaving as naturally as possible. This setup fosters a deeper understanding and appreciation of wildlife and the challenges of conservation. The zoo's layout and habitat design also allow for easy navigation and accessibility, ensuring that all visitors, regardless of mobility level, can enjoy a full and enriching experience.

Singapore Zoo's innovative design and conservation efforts exemplify how zoos can function as educational and environmental conservation centers. The seamless integration of natural habitats and visitor spaces enhances both animal welfare and visitor engagement, setting a benchmark in zoo design and management.

Case Study 3: Bronx Zoo, Bronx, New York (265 acres)



Figure 6: Bronx Zoo Map

Focus: Ecological Design and Urban Wildlife Conservation

The Bronx Zoo, located in New York City, is one of the largest metropolitan zoos in the world, covering 265 acres of park lands and naturalistic habitats. It is renowned for its large and diverse animal collection and its dedication to conservation. The zoo's integration within an urban setting makes it a prime example of ecological design that supports both wildlife and educational initiatives in a densely populated area.

Design Philosophy

The design of the Bronx Zoo emphasizes naturalistic environments that replicate the animals' native habitats. This approach aims to provide the animals with a landscape that supports natural behaviors and healthy living conditions while also offering visitors a more

genuine glimpse into the world of wildlife. The zoo's design also includes several large, unobstructed areas that encourage species to roam and interact in ways similar to their wild counterparts.

Specific Exhibits

- Congo Gorilla Forest: This 6.5-acre rainforest habitat is home to over 400 animals, including critically endangered western lowland gorillas. The exhibit is designed to mimic the African rainforest and uses immersive, multi-sensory experiences to educate visitors about the habitat and the threats these animals face in the wild.
- Tiger Mountain: A naturalistic habitat featuring Amur tigers, this exhibit uses native flora and a design mimicking the Siberian forest to provide an environment that encourages natural hunting and mating behaviors, crucial for the tigers' physical and mental health.
- Madagascar!: Showcasing the unique fauna of Madagascar, this exhibit focuses on species that are seldom seen outside the island. The design incorporates specific climatic and botanical elements that reflect the diverse ecosystems of Madagascar, promoting natural behaviors and conservation awareness.

Conservation Impact

The Bronx Zoo is actively involved in numerous global conservation initiatives and operates one of the most sophisticated wildlife conservation programs in the U.S. It is a leader in the breeding and reintroduction of endangered species, including efforts for the American bison and various amphibian species. The zoo also uses its exhibits to promote conservation messaging about habitat loss, climate change, and biodiversity.

Educational Outreach

Education is a core mission at the Bronx Zoo. It offers a wide range of programs designed to engage audiences of all ages, from preschoolers to adults. These include wildlife camps, teen conservationist programs, and professional development for teachers. The zoo's efforts extend beyond on-site education to include web-based resources and outreach programs that bring conservation awareness into local schools and communities.

Visitor Experience

The Bronx Zoo's layout and design focus on creating an immersive visitor experience that educates and inspires. Each habitat is designed to provide clear, unobstructed views of the animals, often with multiple viewing angles and informational displays that explain the ecological roles of the species observed. The zoo also includes interactive elements, such as digital kiosks and mobile app guides that enhance the educational value of each visit.

By creating a space where city dwellers can connect with nature, the Bronx Zoo plays a crucial role in urban conservation education and advocacy. Its design and programs demonstrate how zoos can function as vital bridges between urban populations and the global efforts needed to conserve biodiversity.

Case Study 4: Taronga Zoo, Sydney, Australia (69 acres)



Figure 7: Taronga Zoo Map

Focus: Technological Integration and Conservation Leadership

Taronga Zoo, located in Sydney, Australia, is not only a premier tourist attraction but also a leader in conservation and wildlife research. Known for its picturesque setting overlooking Sydney Harbour, Taronga Zoo combines innovative exhibit design with cutting-edge technology to promote wildlife conservation and provide educational experiences that reach beyond its geographical location.

Design Philosophy

Taronga Zoo's design philosophy centers around creating environments that foster natural animal behaviors while ensuring the well-being of its inhabitants. The zoo is designed to mimic natural ecosystems as closely as possible, promoting the physical and psychological health of the animals. Additionally, Taronga utilizes sustainable, in-zoo technology to enhance visitor engagement and education, making it a pioneer in integrating digital tools into zoo experiences.

Specific Exhibits

- The Elephant Sanctuary: This exhibit is a standout feature, offering a vast, enriched environment for Asian elephants. It includes varied terrain, bathing pools, and hidden food treats to encourage natural foraging behavior, all designed to mimic the elephants' natural habitats as closely as possible.
- The Sumatran Tiger Trek: An immersive experience that transports visitors to the Sumatran rainforest, aiming to raise awareness about habitat destruction and the plight of tigers in the wild. The exhibit uses augmented reality to engage visitors, providing a deeper understanding of the ecosystem and the conservation efforts in place.
- The Great Southern Oceans Exhibit: This expansive exhibit showcases marine life from Australian waters, featuring seals, sea lions, and penguins in habitats that replicate their natural environments. Innovative water management systems mimic natural currents and tides, essential for the well-being of marine species.

Conservation Impact

Taronga Zoo is at the forefront of numerous global conservation initiatives and operates a significant wildlife rescue and rehabilitation program. It is heavily involved in breeding programs for endangered species, such as the Corroboree frog and the Regent Honeyeater. The zoo's conservation efforts are also extended through its wildlife hospital, which treats over 1,000 animals a year.

Educational Outreach

Taronga Zoo offers an extensive range of educational programs that cater to all age groups. This includes behind-the-scenes tours, keeper talks, and a zoo mobile program that visits schools. The zoo also offers digital education sessions and virtual reality experiences, making wildlife education accessible to a global audience.

Visitor Experience

Taronga Zoo enhances visitor experience through the use of technology such as interactive apps, augmented reality trails, and digital information panels that offer in-depth information about the animals and conservation messages. These tools not only enrich the visitor experience but also allow for personalized tours and self-guided exploration, making each visit unique.

Technology and Innovation

Taronga Zoo is known for its use of technology not only to enhance the visitor experience but also to improve animal welfare. This includes habitat monitoring systems that adjust conditions automatically and the use of drones for surveillance and monitoring of large habitats. Such technological integrations are crucial for ensuring the health of the animals and the safety of the zoo environment.

In summary, Taronga Zoo exemplifies how modern zoos can use design, technology, and education to promote conservation and provide a deep, engaging experience for visitors. Its commitment to sustainability and wildlife conservation makes it a model for zoos worldwide, demonstrating the potential of zoos to be proactive conservation hubs in the Anthropocene.

Global Leaders in the Zoological Network:

The case studies of Woodland Park Zoo, Singapore Zoo, Bronx Zoo, and Taronga Zoo collectively demonstrate the transformative role modern zoos can play in the Anthropocene. Each institution embodies a commitment to the principles of landscape immersion, technological integration, and conservation leadership, showcasing how zoos are evolving beyond mere exhibition spaces to become proactive agents of biodiversity preservation.

Woodland Park Zoo's early adoption of the landscape immersion philosophy set a precedent for subsequent zoos, emphasizing habitat mimicry and visitor immersion. Singapore Zoo took this further with its open-concept designs that not only reduce physical barriers between visitors and animals but also foster a deeper understanding and respect for wildlife. Bronx Zoo's focus on detailed thematic exhibits like the Congo Gorilla Forest integrates educational narratives directly into the visitor experience, highlighting the interconnectedness of species conservation and habitat protection.

Taronga Zoo, with its emphasis on cutting-edge technology and extensive conservation programs, illustrates the potential of zoos to engage global audiences and extend their impact beyond physical boundaries. The integration of digital tools not only enhances the visitor experience but also plays a critical role in animal welfare and habitat monitoring, ensuring that the zoo operates as a modern conservation hub.

Together, these zoos illuminate the multifaceted roles that zoological parks can fulfill—educators, conservators, and innovators. They demonstrate that through thoughtful design, strategic use of technology, and a steadfast commitment to conservation, zoos can significantly contribute to the preservation of biodiversity. They also serve as models for how zoos can foster an appreciation for wildlife and inspire action towards conservation in their visitors. This synthesis not only aligns with but also reinforces this thesis' argument that modern zoos must evolve in response to the dynamic challenges of the Anthropocene. By adopting and refining these innovative practices, zoos can continue to play a crucial role in wildlife conservation, education, & animal welfare, ultimately ensuring that they remain relevant and impactful as conservation-centric landscapes in a rapidly changing world.

Integration of Landscape into Zoo Design: Ecological and Economic Factors

Ecological Impact:

The integration of landscape architecture into zoo design has a profound ecological impact. By designing zoo enclosures that mimic natural habitats, landscape architects can support a more sustainable zoo ecosystem within urban areas. This approach supports local biodiversity by incorporating native flora that attracts and sustains local fauna, contributing to urban biodiversity conservation. For example Bisgrove states,

The Phoenix Zoo was even the site of the first known sighting of a Trumpeter Swan in the Phoenix Metro area in 2018 (12News 2018). India's Delhi Zoo has long acted as a crucial nesting ground for hundreds of wild, near-threatened Painted Storks, and one study even used the site to research the species' reproductive behavior and threats (Meganathan and Urfi 2009). Though currently underutilized, it is possible that many

zoos around the world offer similar study sites for species of conservation interest. These practices not only benefit the zoo's ecosystem but also serve as live models for sustainable practices in urban landscaping.

Natural Ecosystems & Habitat Connectivity:

Landscape architecture principles prioritize the integration of natural ecosystems into design planning. By incorporating elements such as native vegetation, natural water bodies, and terrain variations, zoo enclosures can provide habitats that closely mimic the natural environments of different species. This approach promotes the natural behavior of animals, reduces stress, and increases overall animal welfare. Landscape architects often emphasize the importance of connectivity in ecological planning. In zoos, this can translate into design strategies that allow different animal habitats to be interconnected without human interference. For instance, creating overhead trails (Zoo360) or submerged passages that animals can use to move between enclosures can simulate a more natural living environment. Principles of accessibility and visitor engagement are central to landscape architecture and can be effectively applied to zoo design. Recreational areas within a zoo provide an essential opportunity for people to engage with their local environment. Patches that include parking lots, food venues, and animal exhibits are all interconnected by public pathways. As visitors navigate the zoo, families collectively decide on their route for the day. This exploratory space within the zoo offers significant opportunities for individuals to connect with each other, as groups create shared experiences and meanings through their interactions with wild animals (Clayton et al. 2009). Thoughtfully planned pathways, viewing areas that allow close yet safe interaction with nature, and educational displays can enhance the visitor experience and increase awareness about conservation issues.

Economic Impact:

Economically, investing in landscape-integrated zoo designs can lead to long-term savings and attract more visitors. Naturalistic enclosures are more appealing to visitors, potentially increasing ticket sales and memberships. Landscape architecture emphasizes the aesthetic integration of design elements with natural surroundings. In zoos, this can mean designing enclosures that not only house animals safely but also blending seamlessly into the surrounding landscape, enhancing the visual appeal for visitors and creating a more immersive experience.

Enhanced Visitor Experience:

By applying principles of landscape architecture, zoos can create captivating and educational landscapes that attract more visitors. Increased footfall can translate to higher ticket sales, more memberships, and greater funding opportunities. Investing in ecologically sound designs can reduce operational costs in the long term. For example, using native plants in landscaping reduces water and maintenance costs (Ferguson, 1987). Sustainable design elements like solar panels and biofiltration systems decrease energy costs and waste, respectively. There is also a marketing edge to be gained from being seen as a green, ecologically responsible institution, which can attract sponsorships and partnerships with environmentally focused organizations. Moreover, the use of native plants and sustainable practices reduces maintenance costs by using less water and fewer chemicals compared to traditional landscaping.

Experiential Quality and Human-Animal Interactions: Ecological and Economic Factors

Ecological Impact:

Improving the experiential quality of zoos through thoughtful design directly impacts the animals' psychological and physical well-being. Enclosures that allow for natural behaviors, such as foraging, climbing, or even semi-migratory movements, contribute to healthier animals and lower veterinary costs. Michael J Renenr states, “By displaying animals in settings resembling their natural habitat – and setting the scene for visitors to imagine themselves in that habitat – the hope is to instill in visitors, who might never see a lion in its element, a passion for its preservation” (The Conversation). From an ecological perspective, healthier animals can contribute better to breeding programs essential for conservation efforts. Furthermore, zoos that successfully simulate natural environments can participate in reintroduction programs, helping to restore populations in the wild, thus playing a direct role in ecological conservation efforts.

Economic Impact:

On the economic side, zoos that provide enriching, educational, and engaging experiences are likely to see higher visitor retention rates, increased spending per visit, and enhanced community support through memberships and donations. Educational programs that leverage the unique human-animal interactions possible in well-designed zoos can generate additional revenue streams while fostering a public understanding of ecological conservation needs. Additionally, zoos with a reputation for high standards in animal welfare and visitor experience are more likely to attract funding and grants from conservation and educational bodies.

Synergistic Potential:

The synergy between ecological and economic factors in zoo design is clear: ecologically sound practices can boost economic outcomes, and vice versa. By embracing landscape ecology principles and focusing on creating immersive, educational experiences that respect both animal welfare and the visitor's desire for interaction, zoos can position themselves as leaders in conservation while operating sustainably and profitably.

Flipping the Perspective: How Zoo Design Informs Landscape Architecture

While landscape architecture can greatly enhance zoo design, the influence of zoological design on landscape architecture is equally significant.

The idea of "heterotopias" as described by Michel Foucault, describes a world within which all other alternate realities and cultures are represented and contrasted at the same time. Zoos in urban spaces fall into this description. They are reenactments of utopian conditions as depicted in biblical occurrences such as Noah's ark or the Garden of Eden where human and animals interacted freely and shared the same space (Alasheen, 25).

This reciprocal relationship allows for innovative applications of zoo design principles in broader landscape architectural practices, emphasizing habitat connectivity, the use of native plants, and ecological restoration.

Habitat Connectivity in Urban Planning:

Zoo designs that focus on creating interconnected habitats for species mobility can inspire similar strategies in urban landscape planning. "Zoos, with their generally significant amount of horticulture, shelter, and perennial water sources also act as stopover sites for the migration of many species of birds," (Totha, 2019). [Another] recent study demonstrated the

value of zoos as habitat for small mammal species (Elwell et al. 2021). The concept of green corridors or ecological bridges, often used in zoos to allow animals safe passage between different habitats, can be applied to urban settings to support wildlife movement across fragmented landscapes. “Today, zoos are increasingly recognized for the value they pose to native species and human visitors as a reservoir of natural surroundings in urban settings.” (Elwell et al. 2021). This approach promotes biodiversity and ecological continuity in densely populated areas where natural habitats are often isolated by urban development.

Native Plant Utilization:

Zoos often use native plants within enclosures to simulate natural environments and support local wildlife species, which can be a model for urban landscaping. Landscape architects can take cues from zoo horticulture by integrating native plant species into public parks, roadside plantings, and residential landscapes. This practice not only conserves water and reduces maintenance costs but also enhances local biodiversity and resilience against pests and diseases.

Ecological Education and Public Engagement:

Zoo designs that incorporate educational elements about species and habitats can influence landscape architecture to adopt similar approaches in public spaces. Educational signage, interactive displays, and guided tours that are commonplace in zoos can be adapted to parks and green spaces to educate the public on local ecology, conservation issues, and the importance of sustainability.

Microhabitat Creation

Zoos are adept at creating microhabitats that cater to the specific needs of different species. During the design phase of America's first major landscape immersion exhibit at Woodland Park Zoo, architects Jones and Jones meticulously analyzed slight variations in environmental conditions at the site to map out microclimates (Hancocks 2001). This principle can inform the design of urban landscapes to include varied microenvironments, such as butterfly gardens, bird sanctuaries, and aquatic habitats. These features not only enhance the aesthetic and recreational value of urban spaces but also play crucial roles in urban ecology by providing niches for various organisms.

Innovative Use of Space

Zoos often need to design compact yet complex habitats due to spatial limitations, which is a challenge also faced by urban landscape architects. Bisgrove states,

Some zoos have found very simple natural elements to be an especially charming part of the zoo experience. Constructed with the surplus dirt from a publicly funded excavation project in the 1930s, “Monkey Hill” at the Audubon Zoo in New Orleans, has long been—albeit somewhat falsely—credited as the tallest point in the famously low-lying city, standing a meager 26 feet above sea level (Campanella 2014). Nearly a hundred years later, the children of New Orleans continue to find endless joy log-rolling down the hill, one of the few points of geographic elevation in the region (Campanella 2014).

Sometimes, very simple elements of heterogeneity, such as relatively minor differences in plant density or elevation can make a world of difference for people’s connection to the natural world.

Learning from zoo enclosure designs, landscape architects can maximize small urban areas by creating multipurpose landscapes that serve ecological, recreational, and aesthetic functions simultaneously. Some other facilities, such as the Arizona-Sonora Desert Museum outside of Tucson, have used traditional zoo techniques with a beautiful backdrop with great success. By controlling sightlines, minimizing the visible barriers between visitors and animals, and by incorporating exhibit infrastructure seamlessly into the beautiful desert surroundings, the Desert Museum makes it easy to suspend disbelief to a whole new degree, and actually leaves visitors startled when they suddenly find themselves face to face with a coyote (Grazian 2015). This sort of immersion sparks curiosity, excitement, and passion for the natural world.

Ethical and Conservation-Oriented Design

Zoos are increasingly designed with a strong emphasis on conservation, which can inspire landscape architects to prioritize ecological and conservation goals in their projects. This approach advocates for designs that do not just accommodate human needs but are also mindful of wildlife and ecosystem services, promoting a more holistic view of human-environment interactions. By adopting zoo-inspired principles, landscape architecture can evolve to address contemporary environmental challenges more effectively, enhancing urban livability and ecological health. This synergy between zoo design and landscape architecture demonstrates a profound shift towards more integrated and thoughtful approaches to designing human and animal habitats.

Bridging Captive and Wild Habitats: Mitigating Displacement Across Environments

This thesis wishes to extend the concept of displacement from the confines of zoos to the broader ecological impacts on wildlife caused by human expansion and climate change.

Displacement, characterized by animals encountering radically altered habitats, manifests not only in captive settings but especially in human-altered or impacted natural landscapes. For example, tigers increasingly venturing into villages in India triggering community relocation (Jain 2016), polar bears appearing in human settlements in the Arctic (Larson 2020), and mountain lions in urban California (Riley 2014) exemplify wildlife adapting to shrinking habitats and changing climate conditions. The principles of immersive zoo design, which aim to mimic natural habitats and foster natural behaviors, can also inform strategies for habitat management in wild settings. By applying similar landscape ecological principles to both zoo and natural habitat design, conservation efforts can create buffer zones, wildlife corridors, and protected areas that not only preserve the ecological integrity of these regions but also reduce human-wildlife conflicts. Moreover, this dual focus underscores the synergy between the methodologies used in zoo design and broader conservation tactics. Just as immersive zoo enclosures can educate and inspire zoo visitors about the importance of natural behaviors and habitats, similarly designed protected areas can serve as educational and eco-tourism sites, promoting conservation awareness and generating funds to support ongoing conservation efforts.

Where is Wilderness?

The accelerating expansion of human civilization, compounded by the pressures of climate change, is eroding our sanctuaries of true wilderness, places ‘untouched’ by rapid human expansion. As urban sprawl extends and climate variability intensifies, the interface between human and natural environments is no longer distinct but increasingly blurred. Our encroachment poses significant challenges to biodiversity and disrupts the delicate balance of ecosystems worldwide. True *wilderness*, characterized by its relative inaccessibility and minimal human impact, serves as a critical refuge for diverse species, supporting complex ecological

processes that are often disrupted or destroyed by human activities; The world map illustration, "Wild World" by New Zealand cartographer Anton Thomas, vividly captures this concept by depicting a world without political borders, focusing solely on native wildlife, thereby visually reinforcing the idea that humans are not separate but integral to this natural ensemble.

Humans are *not* separate from nature and never have been. We are part of a historic, ecological tapestry, and the current dominant models of human settlement and economic development often neglect this intrinsic connection. The prevailing approach focuses on human needs and convenience at the expense of ecological and other species' considerations, leading to a model of living that does not support multi-species integration. Our current model prioritizes economic growth and infrastructural expansion, typically sidelining the essential ecological functions and the needs of other species that also inhabit the Earth.



Figure 8: Wild World Map, Anton Thomas, 2023.

Species Survival Centers:

In this increasingly fragmented world, both wild and zoo animal populations are becoming similarly limited, isolated metapopulations. In response, the integration of zoo populations with their wild counterparts through re-introduction, head-starting, and cross-fostering programs is gaining importance. These efforts not only aim to supplement the continued recovery of threatened species but also provide the necessary genetic flow to help species adapt to the dynamic environment of the Anthropocene. This blending of conservation practices highlights the potential for zoos to serve as pivotal players in the broader ecological network, aiding in the adaptation and survival of species in a changing world (Scharis and Amundin 2015). Recently, the Association of Zoos and Aquariums' (AZA) Species Survival Program (SSP) for Mexican Wolves collaborated with the United States Fish and Wildlife Service (USFWS) to cross-foster twenty captive-born Mexican wolf pups into various wild packs across Arizona and New Mexico (Arizona Game and Fish Department 2020). This initiative demonstrates how zoos can serve as genetic reservoirs for wild populations by more effectively integrating captive zoo populations into broader wildlife management strategies.

My experience interning at the Freeport-McMoran Species Survival Center (SSC), a non-public derivative of the Audubon Nature Institute in Belle Chase, Louisiana, further exemplifies these efforts. As a hoofstock intern, I was directly involved with species such as giraffes, okapis, bongos, elands, sitatungas, sable antelopes, barasinghas, and more. The center raises mainly African hoofstock, which plays a crucial role in diversifying the genetic pool within American zoos and supports on-the-ground conservation efforts in native habitats, but also serves as one of the cornerstones of sandhill and whooping crane recovery in the United States. This hands-on experience underscored the importance of maintaining genetic diversity and resilience through

proactive conservation practices, reflecting broader themes of the evolving role of zoos and conservation strategies in the Anthropocene. These practical efforts at the SSC highlight how zoological institutions can act as conservation hubs, merging captive breeding with re-introduction strategies to bolster species survival and ecological integrity globally. These centers illustrate a forward-thinking approach to conservation that stretches beyond the confines of zoo walls and into the wild habitats they aim to preserve. By integrating zoo-based populations with those in the wild, and employing thoughtful, research-driven habitat designs, these programs can significantly amplify the impact of conservation efforts. I was engaged in a brief, incomplete research project at SSC that investigated three species of ungulate's use of their 46-acre yard and analyzed stress response. In doing this, we hoped to gain a greater comprehension of how the animals were using their naturally wooded space and facilitate the creation of management solutions that would foster a more positive welfare environment (Ross 2016). The project was cut short due to Hurricane Ida on August 29th, 2021; however, the study had ambitious goals to better understand animal behavior in a nontraditional zoo environment. Having this hands on experience directly influenced my appreciation of naturalistic enclosures and for observing animal behavior.



Figure 9: Collage of Images taken at the Freeport-McMoran Species Survival Center:

Summer 2021

Integrating Biodiversity in Urban Development: A Path to Sustainable Coexistence:

The loss of these areas is not merely a loss of space but also of the genetic reservoirs and biodiversity that sustain global ecological health. For instance, the Amazon rainforest, often dubbed the "lungs of the planet," is shrinking at an alarming rate due to deforestation for agriculture and logging. Similarly, the melting Arctic ice disrupts the habitats of polar bears, walruses, and numerous marine species, demonstrating how climate change directly transforms pristine natural environments.

To foster a sustainable coexistence, it is imperative to adopt principles of integrated living that recognize and incorporate the needs of all species into urban planning and development strategies. This includes designing cities and human settlements that are not only efficient and sustainable for humans but also conducive to wildlife and plant life. Urban green

spaces, wildlife corridors, and eco-friendly architecture can help bridge the gap between human and wildlife habitats, promoting biodiversity even within densely populated areas. For example, initiatives like the creation of green roofs, vertical gardens, and the restoration of urban waterways can enhance urban biodiversity and provide crucial stepping stones for wildlife in cities. Supporting the ideas of integrated living, therefore, involves rethinking and reshaping our urban landscapes and development policies to create a harmonious balance that benefits all species. This holistic approach is essential not only for the survival of myriad species but also for the well-being of human societies, ensuring that the planet remains a vibrant, diverse, and sustainable home for all its inhabitants.

Conclusion:

In conclusion, this thesis has charted the transformative journey of zoos from their inception as mere curiosities to their current status as vital nodes in the global network of biodiversity conservation. The discourse herein not only revisits the historical underpinnings that have shaped zoological institutions but also critically examines the challenges and opportunities they face in the Anthropocene—a time marked by human-induced changes to the Earth’s ecosystems.

Through a rigorous examination of ethical considerations, design innovations, and case studies, we see that modern zoos are uniquely positioned to serve as educational platforms, genetic reservoirs, and conservation advocates. However, the journey is far from complete. The integration of cross-disciplinary knowledge—from landscape architecture to conservation psychology—underscores the potential for zoos to further evolve and effectively contribute to global biodiversity efforts. Zoos must navigate the delicate balance between their roles as attractions and their responsibilities as conservationists and educators.

Reflecting on my personal experiences, such as my internship at the Freeport-McMoran Species Survival Center, I have witnessed first-hand the potential for zoos to contribute positively to conservation. Yet, this potential is not always fully realized due to various constraints, including financial limitations and public misperceptions. It is imperative that zoos continue to innovate and adapt not only to survive but to thrive in a changing world.

This thesis advocates for a reimagined role for zoos in the 21st century, where they act not only as sanctuaries for species but as proactive agents of change, fostering a deeper public connection to nature through immersive and ethical design. The future of zoos, and indeed of

global biodiversity, will depend significantly on our ability to implement and support these changes.

As the world looks forward, it is essential that all stakeholders—zoo professionals, conservationists, policymakers, and the public—engage in a concerted effort to support these transformations. We must challenge existing paradigms that view zoos merely as venues for entertainment, and promote a broader understanding of their potential to serve as pivotal conservation hubs. Zoos have the opportunity to set examples for ecological stewardship, to serve as educational centers that highlight the interconnectedness of all life, and to promote a conservation ethic among a broader, public audience. In doing so, they will not only ensure their relevance but also enhance their contribution to a sustainable future.

In this critical epoch, the need for comprehensive, integrated approaches to conservation is more urgent than ever. Let us move forward with a renewed commitment to innovation, ethical considerations, and global collaboration in our shared stewardship of the planet's biodiversity. Zoos, in their ideal form, can act as arks of hope and beacons of conservation in the Anthropocene, fostering not only the survival of species but also the thriving of diverse ecosystems around the globe.

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