Environmental Enrichment With an Emphasis on Choice and Control for Captive Elephants

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Introduction

Animals in captivity often suffer a range of ailments – physical, mental, and social. The primary reason for this is that captive environments are unable offer the array of stimuli found in the wild.

Environmental enrichment is the practice of increasing stimuli in captive environments, with the goal being to improve the welfare of the animals living there. Examples of enrichment practices include providing toys, making food acquisition more challenging, and increasing enclosure size. Some zoo designers believe that environmental enrichment will increasingly focus on providing choice and control. Considering that captivity can be defined as a lack of choice and control, it makes sense that offering these freedoms may alleviate some of the stress that accompanies captivity (Coe, 2003).

Starting with the premises that captivity is stressful to animals and that environmental enrichment, particularly enrichment that offers choice and control, can help alleviate stress, this study examines how environmental enrichment might improve the lives of captive elephants. The focus is on elephants because they are especially difficult to house in captivity due to their size, strength, and highly social nature. It is hypothesized that design interventions can give captive elephants greater choice and control in their environments.

A literature review will be used to help examine this hypothesis. There are numerous studies that have evaluated environmental enrichment efforts. A few of these studies have specifically focused on choice and control (for example, Haskell, et al., 2004; Shapiro and Lambeth, 2007; Taylor, 2001), and a few have specifically focused on elephants (for example, Sevenich and Mellen, 1998; Stoinski and Maple, 2001; Taylor and Poole, 1998). As is the nature of scientific research, each study is highly specific, addressing a particular environmental enrichment effort with a particular species and group of animals. The results of these studies will be aggregated, and practices of environmental enrichment will be assessed in terms of spatial design. If the hypothesis – that there are design interventions that can offer captive elephants greater choice and control over their environment – is supported, then a set of general design guidelines will be extrapolated from these specific studies. The expectation is a set of guidelines that will help guide zoo designers in the process of creating better homes for captive elephants.

Chapter 1 – Past, Present, and Future of Zoo Design

"As much as any institution, the zoo is a window on prevailing attitudes and, more broadly, on a culture as a whole. Indeed, how we as humans behave toward animals, and toward nature in general, reflects our views of ourselves and our world" (Powell, 1997).

The Earliest Zoos

Throughout their history, zoos have almost always been symbols of power and wealth. The first zoos most likely appeared about 4,300 years ago in the Sumerian city of Ur (Hancocks, 2001).

In the fifth century BC, almost all Greek cities maintained zoos, which the Greek people considered integral in the education of young scholars. Along with institutions such as libraries and botanical gardens, most zoos withered with the fall of the Roman Empire. Zoos were uncommon throughout the Dark and Middle Ages (Hancocks, 2001).

In 1252, England's Henry III established a royal menagerie inside the Tower of London, where visitors could avoid paying an entrance fee if they brought a small animal to be fed to the lions. In Europe in the thirteenth through fifteenth centuries, most powerful men owned lions at the very least. However, none of these collections could compare to that of Montezuma II in Tenochtitlan (now Mexico City). Animals in this collection were treated extremely well by European standards. Spain's Cortez destroyed the collections in 1519 as part of his attack on the Aztec empire. Other noteworthy menageries of the time were those of India's Akbar the Great (Fig. 1). As in Tenochititlan, animals here were treated well, living in spacious enclosures unseen in Europe. Akbar's collections were open to the public, and at the entrance to each was the message, "Meet your brothers. Take them to your hearts, and respect them" (Hancocks, 2001).

Figure 1. Akbar the Great rides an elephant. Image via Wikipedia.

Zoos and Science

Initially, zoos strived for mere physical survival of captive inhabitants. Menageries and zoological gardens, as they were called, were successful if they were able to keep animals alive. Veterinarians struggled to determine appropriate diets and medical care for animals living solitarily in concrete, barred cages. Zoo managers and designers knew little about the animals in their care.

The London Zoo opened its doors in the early 1800s (Fig. 2). The large, public zoo set the standard for an eruption of new zoos throughout the world in the 1800s and has influenced zoo design to this day. In Europe, a comfortable middle class with an interest in education and science enabled an unprecedented level of popularity for the zoo. While naturalistic landscaping served to educate the public about the animals' habitats, the animals themselves were displayed in sterile and orderly taxonomic groupings.

> The tradition of setting animals on display in taxonomic groupings, introduced at the London Zoo in the early nineteenth century, has proven extremely tenacious, probably because it appeals to scientific logic and the strong sense of catalogued order that prevails among collectors (Hancocks, 2001).

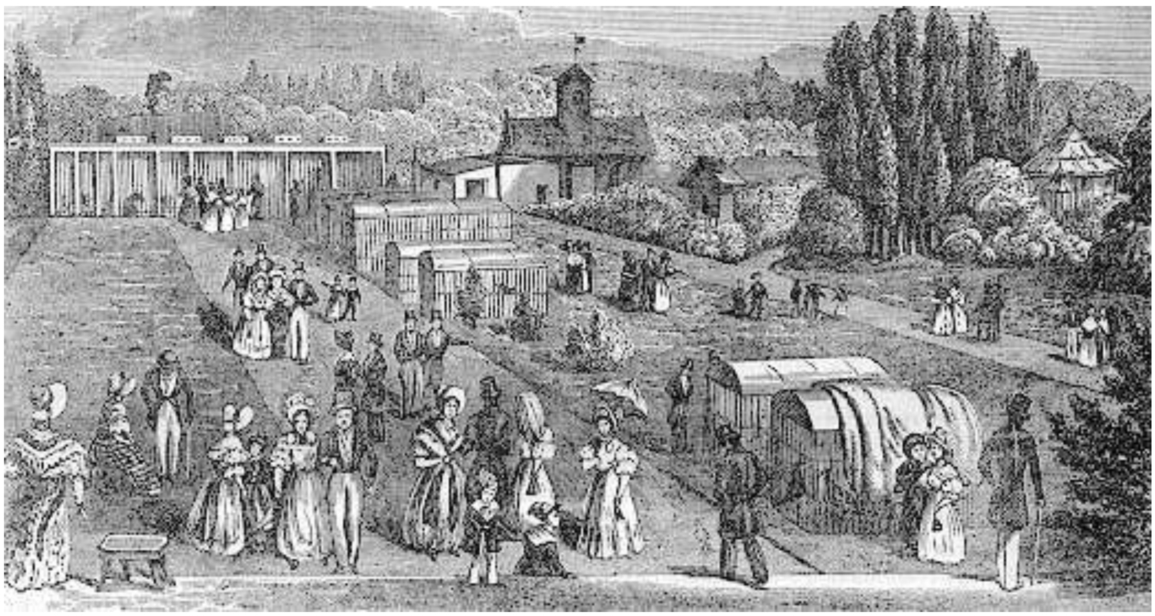

Figure 2. This illustration depicts the London Zoo in 1837. Note the orderly, isolated enclosure arrangement. Image via Hermes.

The first exotic animal publicly exhibited in the United States was most likely a lion in Boston in 1720 (Hancocks, 2001). The first menageries followed in the late 1700s. These entities disappeared during the Civil War. The country had its first permanent zoo when New York's Central Park Zoo opened its doors in 1860. This and other early zoos in the United States did not start off on firm footing. In 1891 the House and Senate agreed to establish a national zoo. Animals for this zoo had to be acquired principally by donation, which resulted in acquisitions such as raccoons, opossums, and unwanted pets.

> The zoo was in such dire straits that when a kangaroo happened to be for sale for seventy-five dollars, a local pet shop owner purchased it and traded the animal to the zoo for guinea pigs, at fifteen cents each. It took three years of breeding guinea pigs to clear the debt before the kangaroo belonged to the nation (Hancocks, 2001).

Animal Welfare and Environmental Awareness

In the 1900s, zookeepers' desire to have animals reproduce led them to reexamine animals' social arrangements, and animals that had been living solitarily for years were united with other members of their species. Zoos began creating larger displays and modeling them after the animals' natural habitats to encourage natural behavior, such as reproduction. In this era of zoo thought, fields such as veterinary care, animal training, architecture, and landscape architecture are collaborating to a greater degree than ever before, therefore providing more informed care for captive animals.

The work of Germany's Carl Hagenbeck, which imitated idealized natural habitats, offered a new model for zoo design. His designs utilized bar-less containment methods and often featured mixed species displays based on region of origin (Fig. 3). Hagenbeck designed zoo enclosures like theater sets, positioning each enclosure behind and slightly higher than the previous. They were separated by hidden moats. Artificial rockwork and plantings carefully modeled after animals' natural habitats concealed holding quarters.

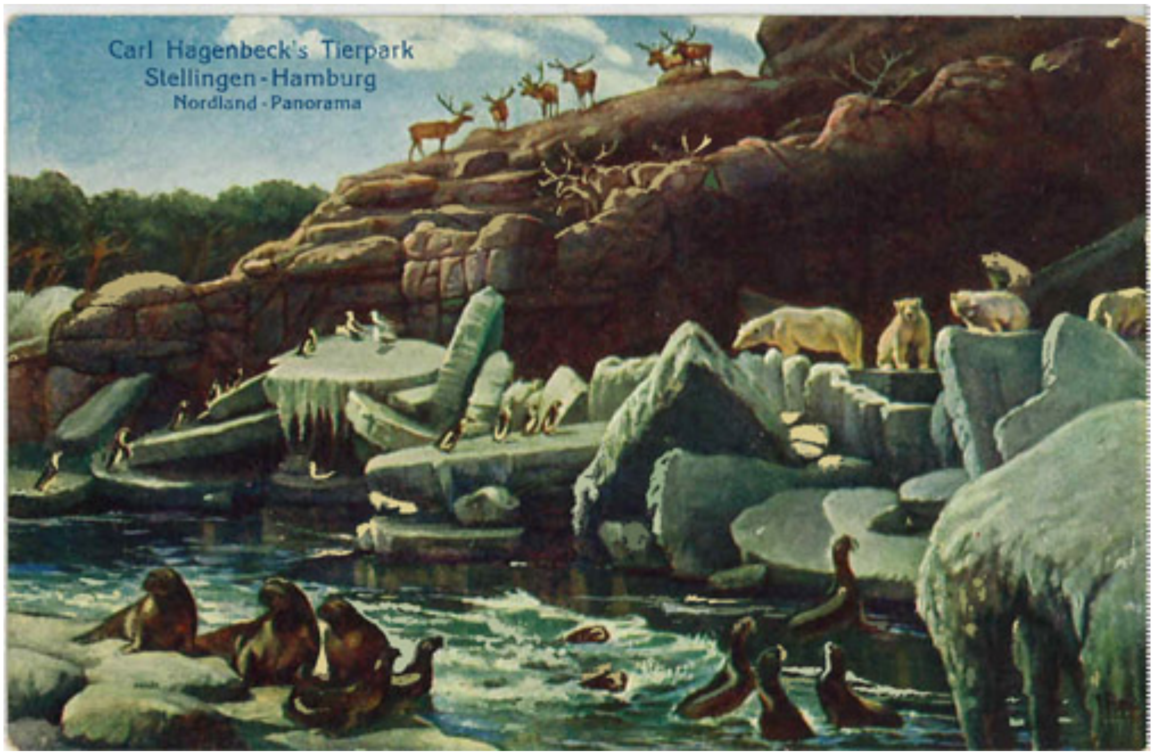

Figure 3. Illustration of Hagenbeck's Tierpark in Stellingen, Germany, depicts the theater-like layout of his zoo designs. Image via Smithsonian Libraries.

Of his zoo, Hagenbeck said,

> I desired, above all things, to give the animals the maximum of liberty. I wished to exhibit them not as captives, confined within narrow spaces, and looked at between iron bars, out as free to wander from place to place within as large a limit as possible, and with no bars to obstruct the view and serve as a reminder of captivity (Hancocks, 2001).

The public was enthralled by Hagenbeck's dramatic new method of zoo design, and zoos across the world began to emulate his work. However, many of the new designs were mere imitations, uninspired by natural habitats. Rather than taking the opportunity to educate visitors about the geology of animals' natural environments, many zoos today still feature masses of unrealistic rockwork.

"In 1950 Heini Hediger published his book *Wild Animals in Captivity*. No architect or zoo manager since then can be justified in not knowing how to care for zoo animals and properly design for their needs" (Hancocks, 2001). Hediger, a zoologist, promoted a biological approach to zoo design. He emphasized that the quality of the space, not just the size, was critical in meeting the needs of captive animals.

Zoos began to implement what would now be termed *environmental enrichment efforts* (Hancocks, 2001). Environmental enrichment is the enhancement of captive environments to provide animals with greater stimulation. By reducing boredom and promoting the expression of natural and instinctive behaviors, the practice aims to address the causes of many behavioral and mental problems animals face in captivity. Environmental enrichment will be addressed in greater detail later in this paper.

Zoos began to focus more on conservation and education in the second half of the 20th century. In the 1970s, the American Zoo Association declared that conservation was its highest priority. In an effort to educate the public about conservation, zoos increasingly displayed animals in naturalistic habitats. "For the wild animals themselves there is only one appropriate context: their wild habitat. Seen separate from this they become merely oddities" (Hancocks, 2001). Research suggests that visitors to zoos with an educational focus leave with more respect for the animals. "The most compelling and obvious impact on visitor attitudes toward wildlife is the way that zoo animals are presented. This is why quality of exhibit design is of paramount importance" (Hancocks, 2001).

Today's Zoos

Since its doors opened in 1895, the Bronx Zoo has been one of the most progressive zoos in the world. In the 1960s, the zoo made the unique decision to establish an in-house design team, responsible for designing the buildings, exhibits, and interpretation in a coordinated fashion. More recently, the zoo was one of the first to encourage visitors to participate in efforts to protect endangered habitats throughout the world.

The 1976 long-range plan for Seattle's Woodland Park Zoo may have been the first to declare the animals as the primary clients. It was also the first such document to be prepared by landscape architects, of the firm Jones & Jones (Hancocks, 2001). Seattle's mild climate allows for several bioclimatic zones to be represented with a degree of authenticity, and the zoo was reorganized based on these zones. Some climatic zones were represented without the animals that would inhabit them. "For the first time, a zoo was stating that the presence of animals was not necessarily the primary object of the exhibit" (Hancocks, 2001). The concept of *landscape immersion* was introduced at Woodland Park Zoo (Fig. 4). One of the primary goals of landscape immersion is to make evident the importance of natural systems.

> The intention was that by exhibiting animals in landscapes that closely resembled their natural habitat in every possible detail and by immersing the viewer within that same wild habitat, people would subconsciously make connections between the interdependence of certain animals, plants, and habitats (Hancocks, 2001).

This was a bold concept to champion, considering that wild habitats are untidy, and tidiness had been the standard of zoo design for hundreds of years. As untidy as they may appear, landscape immersion exhibits require exquisite attention to detail.

Figure 4. Woodland Park Zoo's brown bear exhibit exemplifies the concept of landscape immersion, with both animals and visitors occupying in the same naturalistic environment. Photo by Monika Ebendoh.

The Arizona-Sonora Desert Museum is another zoo that has pioneered the landscape immersion concept. Also like the Woodland Park Zoo, the Arizona-Sonora Desert Museum has focused on species that live in climatic zones similar to that where it is located (Fig. 5). "If zoos will focus more on exhibits that fit within the confines of their natural environment and rely upon landscape rather than architectural solutions, they can achieve much more for much less" (Hancocks, 2001). Additionally, zoos would be more effective in educating about environmental issues, being able to touch on issues close to home. The Arizona-Sonora Desert Museum's exhibits address more than just the animals: they also educate about subjects such as paleontology and archaeology (Fig. 6). Additionally, the zoo focuses on small creatures, which are often unmentioned in zoos, even though they make up the majority of wildlife.

Figure 5. By featuring predominantly native species, the Arizona-Sonora Desert Museum saves resources and can focus on topics close to home. Photo via Travel Blog Land.

Figure 6. A visitor looks at a paleontology exhibit at the Arizona-Sonora Desert Museum. Photo by Ron Ratkevich.

Disney's Animal Kingdom is the world's biggest zoo, covering more than 500 acres. The zoo focuses heavily on conservation education. Its strengths are its resources and its abilities as a storyteller: no other zoo has been able to create such spectacular displays with such high levels of realism (Fig. 7). Its weakness is its association with a theme park; the animals risk becoming part of just another amusement ride.

Figure 7. The center of Disney's Animal Kingdom is the massive "Tree of Life." Photo via The Weather Channel.

Unfortunately, there are many zoos and designers that emulate the naturalistic exhibits of the zoos discussed above, but that do not subscribe to the underlying philosophies.

> When medieval monks were given the task of copying Latin and Greek manuscripts, they usually did not understand the texts. The results, after centuries of this blind reproduction, were often nonsense. The beginnings of a similar process are underway with regard to the landscape-immersion philosophy of zoo design" (Hancocks, 2001).

While most zoos today state conservation as an important goal, even some of the best zoos do little in this regard.

> The American Zoo Association published a pamphlet, The New Ark, claiming that 'The survival of the world's endangered wildlife pivots on the conservation and education efforts of modern zoos and aquariums.' If it were true, this would be a terrifying prospect (Hancocks, 2001).

Zoos as we know them are not large enough and do not have sufficient funds to maintain the large number of individuals necessary for any sort of genetic conservation program. (Exceptions are the Bronx Zoo and the National Zoo, which have large tracts of land that they use for breeding purposes.) A more realistic way for zoos to aid in conservation efforts may be for them to become engaged in habitat protection, to focus on saving biodiversity and ecosystems, rather than individual animals or species. Minnesota Zoo has formed a partnership with Ujung Kulon National Park in Indonesia to help save the habitat of the Javan rhinoceros.

It should be remembered that there are still many decrepit zoos in existence, especially in less developed countries. There are also many lackluster zoos in the United States. In 2001, the Department of Agriculture issued permits to over 2,000 zoos. Only 186 of these were accredited by the American Zoo Association (Hancocks, 2001).

The Future of Zoo Design – Providing Choice and Control

Jon Coe is a zoo designer renown for his use of environmental enrichment methods. Coe theorizes that the next stage in zoo philosophy will be that of providing captive animals with greater choice and control in their environments.

> It is time to evaluate our own perceptions of animals' competence to manage their own lives. For millions of years, the antecessors of today's captive species prospered, adapted, and evolved in a world full of opportunity, risk, and intense competition. There were no humans to dice their fruit or call them in. We cannot return these refugees to earlier times, but we can respect their ability to proactively satisfy more of their own behavioral and environmental needs (Coe, 2003).

The challenge for zoo designers is how to offer choice and control within the confines of the captive environment. Presenting animals with a greater array of options is one means of granting them more choice and control. "Rather than living passively in uniform environments mandated by regulation or standard, animals in indoor environments could move through gradients of light, temperature, humidity, color, or smell to select their preferred microenvironments" (Coe, 2003).

Perhaps more rewarding would be giving animals actual control over environmental elements. Elephants could be provided with showers that they operate. Mice could determine the light levels in their enclosures. Heaters, coolers, audio-visual displays – these are all elements that animals are capable of controlling.

Wild animals know how to interact with their environment instinctually and by learning from each other and from experience. Coe suggests that zookeepers could train animals how to interact with and utilize appropriately designed facilities (2003).

Daniel Nuttall has proposed the *animal-as-client* theory for zoo exhibit design (Nuttall, 2007). This theory proposes animal culture as the focus of the zoo design process. By *culture*, Nuttall means both the genetics and behavior of a species, and this concept allows designers to move beyond the nature versus nurture argument. The theory also emphasizes the need for animal participation and collaboration. "In most design professions, once a client has been identified, a stage of information gathering occurs in which client desires are understood" (Nuttall, 2007). Nuttall believes that zoo designers should place more emphasis on this stage of information gathering, in the form of animal preference tests.

Wildlife sanctuaries, particularly those from which animals are released back into the wild, are at the forefront of efforts to provide captive animals with greater choice and control because, in such sanctuaries, animals' competencies must be honed. "If designers repeatedly dilute the richness of animal culture then the process of zoo exhibit design is effectively one of domestication" (Nuttall, 2007). There is no reason not to also honor and maintain the competencies of animals that will remain captive.

The following statements by writer-naturalist Henry Beston and landscape architect and zoo designer Jon Coe frame the inquiry addressed in the remainder of this paper:

> For the animal shall not be measured by man. In a world older and more complete than ours they moved finished and complete, gifted with extensions of the senses we have lost or never attained, living by voices we shall never hear. They are not brethren, they are not underlings; they are other nations, caught with ourselves in the net of life and time, fellow prisoners of the splendor and travail of earth (Beston, 1956).

> Until the time comes, if it ever does, to recreate lost native habitat, we can take the next step by developing facilities and programs respecting the competence of even insects or crustaceans to choose among viable options, giving them greater control of their lives. In so doing, we will be rethinking our basic relationship to nature, redefining captive species not as unfortunate dependents but, as Beston suggests, "other nations" to be respected for what they are as well as what they were. It is this realization, I believe, that will lead us to stage four, creating zoo habitats in which animals more freely engage their lives and ours (Coe, 2003).

The Importance of Choice and Control

> Optimal care and management of zoo animals requires recognition of what each captive animal has gained and what they have lost in the artificial world of the zoo. Only by recognizing the price animals pay for their loss of freedom, naturalness, choice, and control in many aspects of their lives can we effectively mitigate those losses (Laule, 2003).

By definition, the captive environment offers less choice and control than the wild. However, "because of the adaptive significance of some control over, and consequently prediction of the environment, achieving that control is seen as a deep-seated motivation in both animals and humans" (Haskell et al., 2004).

"Many welfare problems arise in situations in which an individual is not able to control one or more aspects of its environment" (Broom, 1991). Numerous studies have demonstrated that a lack of control over one's environment results in higher stress levels. Rats exposed to controllable shocks showed less evidence of stress as measured by weight loss and ulcers than did rats exposed to uncontrollable shocks (Weiss 1968). In Weiss's study, there were three groups of rats - those exposed to shocks that they had no control over, those exposed to shocks that they did have some control over, and those not exposed to shocks at all. The physiological responses of those not shocked and those exposed to controllable shocks were most similar, suggesting that control over the stressor was more significant than the presence of stress.

Long-term exposure to uncontrollable events often leads to a condition known as *learned helplessness*. Depression in some humans is described as a type of learned helplessness – a feeling that failure is inevitable. Animals lacking control over their environment become increasingly passive and are less able to avert and handle stressful situations (Maier et al., 1972). Monkeys reared in situations where they had control over the delivery of food and water were less fearful, more active and inquisitive, and better at coping with stressful situations than those reared in environments where food and water were delivered regularly but non-contingently (Mineka et al., 1986).

Having more choices in one's environment enables the enactment of a wider range of behaviors. Large behavioral repertoires decrease stress by giving more opportunities for performing coping responses (such as withdrawing or redirecting attention) to aversive situations (Carlstead and Shepherdson, 2000).

Further evidencing the value of choice is the fact that individuals perform better when they choose to undertake a task than when they are assigned the same task (Zur, 1989).

Captive environments that portray animals as autonomous beings capable of managing their own lives not only give the animals greater freedom but also engender respect for and understanding of their unique abilities.

In order to honor animal culture in zoos, designers and managers rely on a framework of principles, objectives, and strategies for environmental enrichment. Focusing on the state of design for elephants in captivity, this paper lays out such a framework, with emphasis on providing choice and control.

Chapter 2 – Environmental Enrichment and Animal Well-Being

Problems in Captivity

Even the most complex zoo habitats are still static in comparison to life in the wild – food is provided, safety is assured, and there is rarely any species diversity. Most problems in captivity result from a lack of stimulation, and the main welfare problems in well-kept zoos are usually psychological (Jordan, 2005). Prolonged exposure to environments with low levels of stimulation results in apathy, lethargy, aggression, and slower habituation to new surroundings (Carlstead and Shepherdson, 1994). Many captive animals suffer from chronic stress (Jordan, 2005).

Behavioral responses to captivity may include pacing, ritual head turning, repeated regurgitation and ingestion of food, coprophagia, hyper-sexuality, excessive grooming to the point of self-mutilation, and/or rocking. These abnormal, repetitive behavior patterns are referred to as *stereotypic behaviors*. Scientists think that, in some instances, they may be animals' way of adding novelty to environments lacking in stimulation (Jordan, 2005). Stereotypic motor patterns may also reflect instinctual behaviors that animals are unable to utilize in captivity; for example, a pacing tiger may be responding to its inability to patrol its territory, or a self-mutilating bird may be responding to its inability to peck at the ground in search of food.

Captive animals lack many of the opportunities for exercise that are provided in the wild; their activity levels are generally significantly lower than those of wild animals. It is well known that lack of activity is detrimental to physical and mental health. Even at the best zoos, animals spend most of their time in holding areas that are smaller and more barren than the exhibit spaces that zoo visitors see.

The confines of captive environments are often stressful for their inhabitants, and stress affects growth, reproduction, and disease resistance (Mineka et al., 1986).

Environmental Enrichment

Environmental enrichment is the practice of altering captive animals' habitats to provide them with the stimuli necessary for optimal physical and mental well being. The practice compensates for the inherent deficiencies in the captive environment by increasing environmental complexity and variability.

According to Carlstead and Shepherdson, "environmental enrichment aims to provide environments of greater physical, temporal, and social complexity that affords animals more of the behavioral opportunities found in the wild" (1994). *Physical complexity* refers to the variety of structural, visual, auditory, olfactory, and gustatory stimuli in an animal's environment; *temporal complexity* refers to the way these stimuli change, introducing novelty and variability; and *social complexity* relates to group size and composition. Enrichment helps ensure that all of an animal's senses are engaged, and it can address almost any part of the animal's experience, including physical, feeding, sensory, social, occupational, and human-animal interaction.

Successful environmental enrichment keeps animals occupied, provides a variety of behavioral opportunities, and creates a more stimulating and responsive environment. The purpose of environmental enrichment is to improve captive animals' well being, and factors often associated with improved well being include increased life span, greater reproductive success, decreased stress levels, decreased exhibition of stereotypic and other abnormal behaviors, and improved health.

The benefits of environmental enrichment are numerous. Environmental enrichment increases activity levels – motor activity, exploration, alertness, and diversity of activity. Animals living in enriched environments are more responsive to their surroundings and learn more quickly (Carlstead and Shepherdson, 1994).

Enriched environments decrease the frequency of abnormal behaviors and encourage species-appropriate behavior (Carlstead and Shepherdson, 2000). There are some behaviors that animals may instinctually need to perform, even if resources in the captive environment make these behaviors unnecessary, for example, burrowing or foraging. Preventing these behaviors can result in frustration and/or stress for animals. Environmental enrichment can provide opportunities for captive animals to exhibit their instinctual behaviors (Fig. 8).

Figure 8. At the Roger Williams Park Zoo, an anteater uses its tongue to get food from a custom built device designed to mimic feeding in the wild.

Environmental enrichment reduces animals' stress levels and improves their ability to cope with stress (Mineka et al., 1986). While chronic stress is detrimental to animal health, there is evidence that periodic acute stress may be beneficial, as it increases individual vigilance, responsiveness, and ability to learn (Carlstead and Shepherdson, 1994). The novelty and uncertainty of some enrichment methods can provide this beneficial type of stress (Fig. 9).

Figure 9. At the Edinburgh Zoo, African wild dogs react with interest and trepidation to a new being in their enclosure. Photo by Edinburgh Zoo.

In many species, group dynamics improve after brief periods of stress; some animals are much more likely to reproduce after such instances. Animals in enriched environments have a higher likelihood of reproducing successfully and providing adequate parental care (Carlstead and Shepherdson, 1994).

Examples of Environmental Enrichment

The function of environmental enrichment may be more easily defined than the practice itself, as enrichment efforts vary widely in scope. Giving animals toys and moving animals to entirely new environments are both methods of enrichment. Designers can enrich the environments of lab animals living in small, bare cages, as well as the environments of zoo animals living in large, naturalistic enclosures.

Enrichment design techniques generally follow one or more of the following principles (Shepherdson, 2000):

- Meeting specific behavioral needs, such as the need to find shelter or forage
- Providing an environment in which exploration is rewarded with new and useful information
- Presenting cognitive challenges, such as learning what a trainer is requesting or solving a problem
- Stimulating social interaction

Increasingly, environmental enrichment is offering greater contingency between animal action and environmental reaction – greater control for animals. This section will introduce environmental enrichment in a general sense. It is divided into subsections based on the principles listed above. Bear in mind, however, the most enrichment practices follow under more than one principle. The next chapter, chapter three, will address environmental enrichment as it pertains to elephants specifically. Chapter four will address the future of environmental enrichment – offering greater control – in a general sense and as it pertains to elephants specifically.

Meeting Specific Behavioral Needs

The majority of enrichment efforts may involve food, as it is central to the lives of all animals. Providing different types of food is one of the most basic types of environmental enrichment. Unprocessed foods, such as leaves on branches, whole fruits, carcasses, or even live prey make animals work for their food (Fig 10).

Figure 10. A hippopotamus is given a whole pumpkin to eat at the Paignton Zoo. Photo by Paignton Zoo.

Making food acquisition challenging is an environmental enrichment method that can give animals the opportunity to utilize their natural skills and instincts to acquire food (Figs. 11-14). Food may be hidden, scattered, buried, frozen, placed underwater, or positioned in trees.

Figure 11. An otter at the Blue Reef Aquarium enjoys a fish popsicle – a frozen block of ice containing pieces of fish. Photo by Blue Reef Aquarium.

Figure 12. A giraffe at the Honolulu Zoo uses its long tongue to get food from a suspended jug. Photo by Honolulu Zoo.

Figure 13. At the Honolulu Zoo, Francois Monkeys pick fruit loops from a cotton mop. The fruit loops were strung on the mop, and the mop was hung from the ceiling by a bungee cord. Photo by Honolulu Zoo.

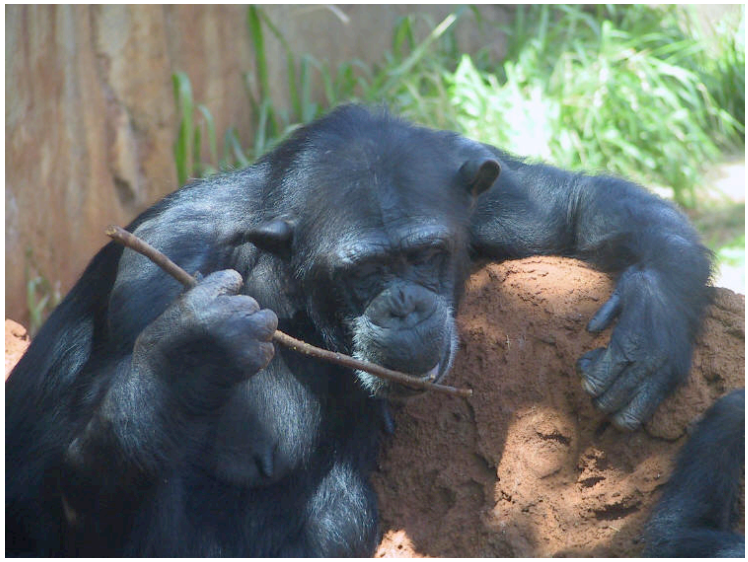

Figure 14. A chimpanzee at the Honolulu Zoo uses a stick to tease food out of a fake termite mound. Chimpanzees will spend hours at the mound. Photo by Honolulu Zoo.

Providing an Environment in Which Exploration is Rewarded

A small number of zoos have systems to rotate groups of animals through a series of enclosures – this is termed *enclosure rotation* (Fig. 15). The practice can work for different territorial groups of the same species, such as different clans of gorillas, or for groups that include predator and prey combinations, such as the orangutans, siamangs, Asian tapirs, babirusas, and Sumatran tigers that rotated exhibits at the Louisville Zoo. The novel spaces (and the scents of other animals that they contain) are stimulating to the animals. Enclosure rotation is most effective when its order, duration, and timing are unpredictable. Positioning habitats of different species adjacent to each other can provide some of the same benefits as enclosure rotation.

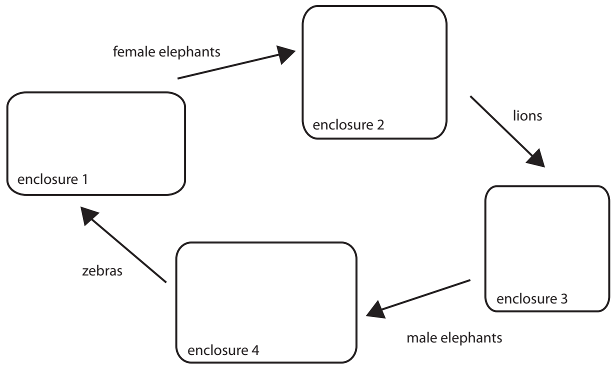

Figure 15. Enclosure rotation allows captive animals to experience enclosures that have housed other animals.

An increase in enclosure size is a valuable type of environmental enrichment. Dividing a space into different functional areas can also make it feel larger.

Adding substrate material such as grass, dirt, straw, mud, mulch, or sand to the environment is enriching (Fig. 16). Substrates enable animals to act out their rooting, digging, and burrowing instincts. They conceal food and foster scents, thus increasing the information content of the habitat. Vegetation that animals can eat, hide in, and play with can also serve as a form of enrichment. Plants can be rotated throughout the year to mimic seasonal changes in the animals' natural environment.

Figure 16. Wendy the woodchuck examines a selection of different substrates at the Museum of Life and Science in North Carolina. Photo by Museum of Life and Science.

Landscape forms, such as water features and variations in terrain, offer novel experiences. If thoughtfully designed, they can allow animals to utilize their natural skills and instincts (Fig. 17).

Figure 17. At the San Diego Zoo, a high point allows meerkats to view their surroundings as they would in the wild. Photo by Robot Claw.

Like variations in the landscape, temperature variations offer novel experiences (Fig. 18). Means of providing temperature variety include heat lamps, warm or cold jets of water (either underwater or in open air), ice blocks or shavings, and temperature-controlled surfaces.

Figure 18. A lion enjoys a heated rock at the Woodland Park Zoo. Photo by Dana Payne.

Some zoos undertake enrichment efforts targeted at specific senses; scent trails, motion activated sounds, and novel textures are examples (Figs. 19-20).

Figure 19. Tigers examine cardboard covered with deer scent at the Folsom Zoo. Photo by City of Folsom.

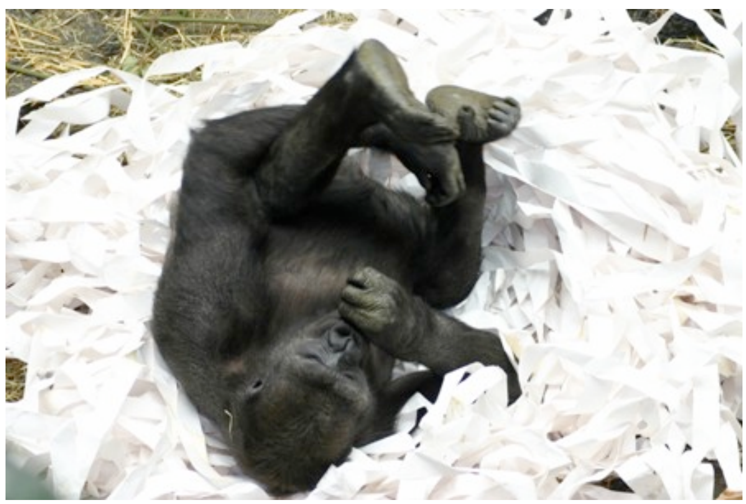

Figure 20. A young gorilla rolls in a pile of paper. The New England Zoo provides experiences like this as a form of sensory enrichment for the gorillas. Photo by New England Zoo.

Toys are common enrichment items (Figs. 21-23). Items that have been used as enrichment objects in zoos include uprooted trees, balls, tires, empty kegs, ropes, cardboard boxes, construction cones, phone books, and mirrors. More complex toys, such as video games, are increasingly common.

Figure 21. A tiger at the Honolulu Zoo plays with a ball. The ball occupied the tigers for five hours after it was introduced to their enclosure. Photo by Honolulu Zoo.

Figure 22. An orangutan plays matching and memory video games at the Atlanta Zoo. Photo by Atlanta Zoo.

Figure 23. Houdini the octopus manipulates his puzzle feeder to find his dinner. Keepers at the Oceanarium Aquarium custom built the feeder, which requires Houdini to use his unique physiology and dexterity to navigate a series of interlocking chambers to get the food inside. Photo by Oceanarium.

Training can serve as a method of enrichment. Positive reinforcement training, which allows animals to participate voluntarily, rather than out of fear, is the preferred method. Negative reinforcement, which relies on fear or anxiety to elicit responses from animals, is inherently taxing to animals' welfare (Laule, 2003). Training offers new experiences and encourages animals to think and learn.

Surprises are enriching! The sudden introduction of an object or experience encourages animals to be inquisitive and alert (Fig. 24).

Figure 24. Spider monkeys react excitedly as the floor of their enclosure is slowly flooded. The Honolulu Zoo flooded the enclosure for four hours to encourage curiosity in the monkeys. Photo by Honolulu Zoo.

Stimulating Social Interaction

Simply allowing animals to spend time together can be enriching. Environments and activities can be designed to encourage social interaction (Fig. 25).

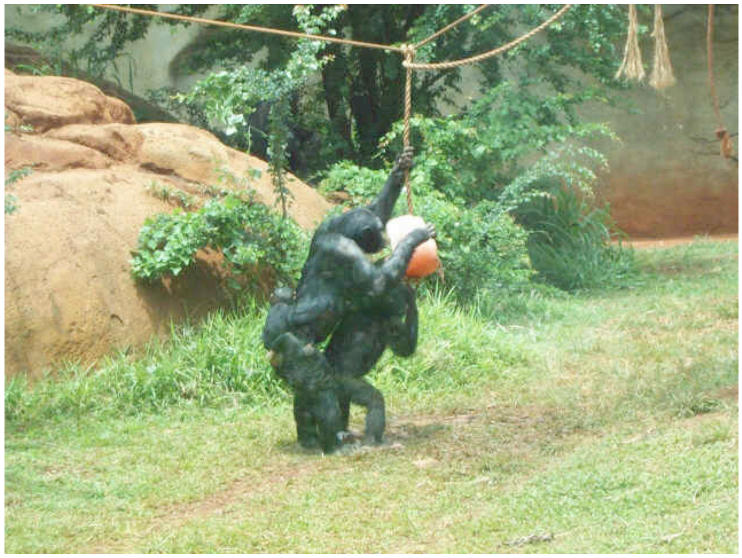

Figure 25. Young chimpanzees at the Honolulu Zoo work together to reach a suspended block of ice with mangoes frozen inside. Photo by Honolulu Zoo.

There are numerous species-specific enrichment methods. Some zoos provide honey-filled logs to brown bears. Keepers at the London Zoo put food at the top of a 20-foot tall telephone pole for the resident tiger. Video cameras that allow surveillance of surroundings have proved to be of interest to chimpanzees, animals that, in the wild, likes to survey their surroundings from the treetops.

New environmental enrichment practices are constantly being devised. Below is a non-exhaustive list of enrichment practices:

- Variations in types of food
- Unprocessed food
- Unpredictable feeding schedules
- Food positioned in hidden or challenging locations
- Rewards that require cooperation between individuals
- Increase of exhibit size

- Exhibit rotation, juxtaposition of exhibits, housing multiple species in one exhibit
- Habitat divided into different functional areas
- Different substrate materials
- Variations in terrain – slopes, boulders, vegetation
- Lookout positions, views
- Water features
- Heated or cooled areas
- Olfactory, auditory, and tactile stimulation
- Toys
- Television, videos, and video games
- Unexpected additions of novel objects/situations
- Introduction of new animals
- Training exercises

"The challenge for exhibit designers is to incorporate such devices effectively into the initial design of new facilities" (Coe, 1992).

Enrichment challenges and planning

An effective enrichment program requires substantial upfront planning and ongoing attention.

Planning

An animal's species-specific needs, individual history, and developmental stage are factors to consider before designing an enrichment program; responses to enrichment efforts may vary with sex, age, genetics, health, and rearing environment. Animals raised in captivity may respond differently to enrichment effort than animals born in the wild. Understanding animals' behavior in the wild is particularly important, as problems in captivity often occur when animals are unable to express their "natural" behavior patterns. "Observations of how animals spend their time when they are in a rich environment are a useful preliminary guide in designing accommodation" (Broom, 1991).

Temporal aspects of animal behavior should be taken into account as well. For example, many wild animals spend the majority of their time in search of food, so some zoos undertake enrichment efforts not only to encourage the animals to forage for food, but to spend a lot of time doing so. How animals spend their time varies by season and developmental stage. The animal's entire lifespan must be planned for.

> The unstated goal of conservation should be to approximate, as closely as possible, an animal's entire life history in a displaced setting … Not only must behaviour patterns be conserved: the successful zoo exhibit allows an animal to display particular types of patterns in an appropriate sequence at appropriate times and appropriate frequencies (Nuttall, 2007).

There is no one-size-fits-all approach to environmental enrichment; it should be specific to species and even to individuals. Appendix 1 of Mellen and Sevenich MacPhee's *Philosophy of Environmental Enrichment: Past, Present, and Future* (2001) provides an extensive list of considerations to take when designing a space for a particular animal.

Tracking Results

Animal caretakers and habitat designers must define the objective(s) of the enrichment program before the design process begins. Ideally, enrichment efforts are proactive rather than reactive. Environmental enrichment is often provided in order to terminate a specific abnormal behavior pattern and/or encourage a specific natural behavior pattern. Mellen and Sevenich MacPhee recommend that enrichment efforts first focus on eliminating abnormal behavior (2001). Priority should then be given to satisfying highly motivated behaviors, such as acquiring food or finding mating partners. Assuming these needs have been met, enrichment efforts may next focus on satisfying exploratory urges by providing novel objects or situations.

Enrichment programs should be applied methodically so that their effects can be observed and documented. Documentation is an important part of any program. Long- and short-term plans, policies, contingencies, and assessments are necessary parts of this documentation. Documentation should also include how each animal responds to the enrichment effort. Ideally, enrichment programs are designed to be self-sustaining. The reality at this point in time is that implementation is often opportunistic, and systematic assessments of these efforts are infrequent (Carlstead and Shepherdson, 2000).

Common Pitfalls

With many enrichment practices, implementation is not a static activity, but something that must be orchestrated by caretakers. The people who will be implementing the program should be included in the design process. If they are excluded, they may not understand or feel comfortable with the new practices, or they may lack a sense of ownership over the program. As a result, they may be less likely to utilize the enrichment opportunity. Their inclusion will also bring greater knowledge to the design process.

A problem with some "enrichment efforts" is that the actual objective is to enrich the human experience, rather than the animal experience. Some zoos undertake these efforts in hopes that animals' behavior will be more exciting to the public. While this certainly can be a positive side effect of environmental enrichment, it should not be the primary goal. While naturalistic enclosures are beneficial in terms of public education, they are not necessarily relevant to the animals. “When using environmental enrichment techniques, we are interested in how animals use objects, rather than how ‘naturalistic’ looking they appear” (Laule, 2003).

Habituation, when animals lose interest in the object or activity provided, is a common pitfall of enrichment efforts.

> Most designers concentrate on the animal exhibit itself, when in fact the enrichment is just as important. If you create a habitat five times bigger, it will just take the animal five times longer to get bored. You must provide frequent and varied activities for the animal to be healthy (Forman et al., 2001).

Stronger, more complex stimuli result in greater and longer lasting responses by animals. For example, moving an animal to a totally new environment would evoke a greater reaction than adding a novel scent to the existing environment. It has also been suggested that enrichment efforts that provide external, rather than internal, reinforcement elicit greater and longer lasting interest and activity (Tarou and Bashaw, 2006). Exploratory behavior on its own is intrinsically reinforced; however, if the exploratory behavior results in finding food, it is extrinsically reinforced. Activities with extrinsic reinforcement are typically more biologically relevant to animals. Responses to enrichment activities may also be improved by making reinforcements more difficult to obtain, of higher quality, less predictable, and less frequently available (Tarou and Bashaw, 2006).

There are some environmental variables that provide diminishing benefits. An example is space allowance. Increasing the size of a tiny enclosure will be beneficial for the animals inside, as would be increasing the size of a massive enclosure. The challenge is determining at what point the benefits are miniscule compared to the effort necessary for enclosure expansion.

Elements added for the sake of enrichment can be harmful to animals. Foods, plants, or substrates could be toxic or cause allergic reactions. Toys might elicit risky activities that result in falling, tangling, or choking. It is important that animals’ use of new enrichment devices be monitored. Devices should have minimal sharp edges and movable parts. If an enrichment program calls for a change in diet, nutritional analysis should be undertaken to ensure that the animals are still receiving sufficient nutrients and not too many or too few calories. A problem associated with enrichment, particularly feeding-related, is that it can increase competition and aggression between animals. Increasing the number of enrichment devices can often help with this (Carlstead and Shepherdson, 2000).

It is difficult to identify all the stressors affecting captive animals, and it is difficult to predict which enrichment methods may help relieve the stress of captivity.

> Designers must realize that our role, while crucial, is also ephemeral. The animals will live on in the habitat for a long time. We can never anticipate all of the animals' needs. Oversights and mistakes will happen. New opportunities will emerge. By acknowledging these factors in advance, we can provide access for equipment to modify exhibits in the future (Coe, 1992).

Determining success

There is no standard way to determine whether environmental enrichment efforts have been successful. Before and after analysis is necessary – this requires a definition of what is to be analyzed.

The best indicators of environmental enrichment success may be the emotional states of the animals, but these are challenging to determine objectively.

> Welfare cannot be seen solely as a scientific concept, since it also reflects political and ethical views of societies. In assessing welfare, we are not only concerned with the physical needs but also with psychologic and emotional aspects of well-being. However, defining psychologic well-being and assessing mental states of animals are clearly very difficult. It requires us to view the world from the animal's perspective rather than our own, usually anthropocentric, viewpoint guided by our limited sensory capacities (Wielebnowski, 2003).

"The study of feelings is central to the assessment of animal welfare. Feelings are not directly observable, but have measurable correlates or consequences" (Kirkden and Pajor, 2006). In other words, while animals' emotional states cannot be directly measured, there are correlating indicators that can be measured.

Successful reproduction, lack of disease and pain, absence of abnormal or detrimental behaviors, exhibition of "natural" behaviors, normal weight range and blood values, stress levels, food consumption, responsiveness, activity levels, exploratory behavior, and longevity have all been used as indicators of well-being, and hence as indicators of the success or failure of enrichment efforts. It is useful to use a variety of indicators to measure welfare (Broom, 1991).

For animals in genetic conservation programs and for animals that will be released into the wild, it is important to encourage naturalistic behavior. However, for the majority of animals in captivity, naturalistic behavior may not be the most important goal. Their success in captivity will depend on their ability to adapt to captive conditions. Behavior that would be abnormal in the wild may actually be beneficial in captivity (Newberry, 1995). Naturalistic behavior is also difficult to define because behavior in the wild can be highly variable, dependent on local environmental conditions and temporal factors. While the exhibition of "natural" behaviors may not be the best measure of whether environmental enrichment programs have been successful, it remains important to provide animals opportunities to utilize their instinctual, evolved behaviors.

While scientific measurements may be the only way for humans to determine whether enrichment efforts have been successful, it is important to keep in mind that the most meaningful goals of environmental enrichment may not be measurable. Gorillas at Seattle's Woodland Park Zoo lived in what landscape architect Grant Jones described as a "six-hundred-square-foot tiled bathroom" for years until the zoo decided to create a complex outdoor enclosure for them

(Powell, 1997). Powell describes the gorillas' reaction upon entering their new enclosure for the first time:

> The females cautiously left the enclosure, and although they exhibited signs of fear hey remained calm. Having never experienced the outdoors – they had never felt the sun, the rain, a breeze; had never seen water flowing as it did in their park – they grew quiet and curious. The sole male among them, however, remained at the door of the enclosure for hours. He entered the park only when his mate returned, took him by the hand, and led him in. Hand in hand they ventured halfway into the park, stopped by a stream, picked up some leaves, dipped them in the water, and chewed them. Then, together, they leaned back and watched the clouds drift by overhead.

Chapter 3 – Elephant Enrichment

There two species of elephants, the African Elephant, *Loxodonta africana*, and the Asian Elephant, *Elephas maximus* (Fig. 26). Unless otherwise specified, the following chapters do not differentiate between the species.

Figure 26. The African Elephant is on the left, and the Asian Elephant is on the right. Photos via Wikimedia Commons.

Elephant Habitat Requirements

The Coalition for Captive Elephant Well-Being, a group of zoo professionals, scientists, academics, veterinarians, animal behaviorists, animal law specialists, and animal welfare advocates, has created an excellent guide detailing the environmental requirements of captive elephants, *Best Practices by the Coalition for Captive Elephant Well-Being* (2005). Much of the information in this section comes from this manual.

Elephants are non-territorial animals that, in the wild, eat and move almost continuously for 20 hours each day. Wild elephants travel between 10 and 20 kilometers (7 to 13 miles) each day within ranges that can be thousands of square kilometers (Moss, 2000). Outdoor areas for captive elephants should allow them to walk a minimum of 10 kilometers (7 miles) per day while engaged in natural behaviors such as foraging, exploring, and socializing (Kane et al., 2003). To achieve this, Poole and Granli recommend at least two square kilometers of outdoor space per elephant (2008). For at least six months of the year, elephants should have access to grassy pasture (*Best Practices by the Coalition for Captive Elephant Well-Being*, 2005). Pasture rotation techniques are advised in order to maintain these spaces. It is important that elephants be allowed outdoors as much as possible, with access during both day and night. Elephant habitats should be constructed only in climates that enable the elephants to comfortably spend the majority of their time outside.

While the USDA does specify minimum habitat dimensions, these requirements are generally considered inadequate for long-term captivity (Forman et al, 2001). Minimum indoor space allowances per elephant, as indicated by the Best Practices manual (2005) are listed in Table 1.

Table 1. Below are minimum space allowances for elephants, according to the Best Practices by the Coalition for Captive Elephant Well-Being (2005).

	Female Elephant (with or without calf)	Male Elephant
Overnight Housing	60 sq. m/650 sq. ft.	110 sq. m/1200 sq. ft.
Winter Housing	185 sq. m/2000 sq. ft.	370 sq. m/4000 sq. ft.

The following are guidelines regarding thermal conditions, according to the Best Practices manual (2005): During the winter, indoor temperatures shall be maintained at a minimum of 16˚ C (60˚ F), unless elephant behavior indicates that lower temperatures are appropriate. Indicators that elephants are too hot include the throwing of water or feces on themselves. If outside temperatures fall below 4.5˚ C (40˚ F), elephants given outdoor access must have simultaneous access to indoor areas. During the summer, indoor temperatures should not exceed 23.5˚ C (74˚ F). Ventilation of indoor spaces should provide four changes of air every hour, with air movement at low velocity to avoid causing drafts. In outdoor areas, large trees or other shade devices must be included in the enclosure design to cast shade over at least a third of the exhibit space at any time of day during warm weather (Figs. 27-28).

Figure 27. A shade structure at the Santa Barbara Zoo shelters animals from the sun. Photo by J&D Fabrication.

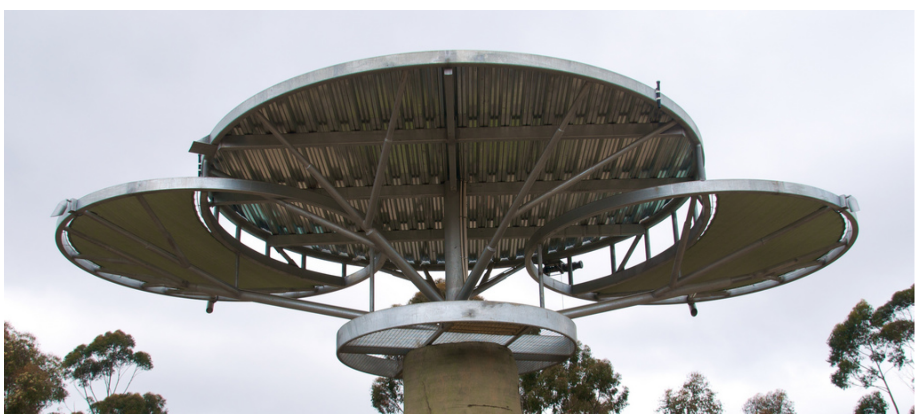

Figure 28. The San Diego Zoo utilizes a large shade structure. Photo by Matthew Ross.

Indoor spaces should utilize windows and skylights to obtain as much natural light as possible (Figs. 29-30). Shelter from light is necessary as well. For artificial lighting, full-spectrum lighting of tropical intensity is ideal (*Best Practices by the Coalition for Captive Elephant Well-Being*, 2005). Artificial lighting in night quarters can employ rheostats to allow gradual dimming and brightening of light. Nighttime light levels should be kept similar to those of starlight or moonlight.

Figure 29. The new elephant enclosure at the Copenhagen Zoo makes copious use of glazing to allow natural lighting for its indoor quarters. The enclosure was designed by architecture firm Foster + Partners. Photo by Foster + Partners.

Figure 30. The Copenhagen glazing is covered with leaf decals, creating dappled light inside. Photo by Nigel Young of Foster + Partners.

Flooring should be made of a non-slip material, ideally a natural substrate such as dirt or straw. Smooth concrete flooring can be grooved or treated with a rubberized or other non-slip coating. In areas where elephants are confined for extended periods of time, soft, waterproof floor covers should be provided. Soft flooring and landscaping can protect against the life-threatening foot problems that elephants frequently experience in captivity (Pennicuik, 2003). If elephants are housed in cool climates, they may be provided with heated flooring during the winter. Throughout the enclosure, it is necessary to have a number of flat, dry areas that can withstand routine cleaning. These areas serve as places to offer feed and minerals to the elephants.

Captive elephant populations differ from wild populations in three primary ways: captive groups are more often exclusively female, are smaller and frequently lack calves, and are more likely to be of mixed-species (i.e. Asian with African elephants) composition (Schulte, 2000).

Elephants are highly social animals that must never be housed alone. “Even a cursory review of elephant species’ natural history furnishes ample evidence that the integrity of the social herd is the single most important element of an elephant’s life” (*Best Practices by the Coalition for Captive Elephant Well-Being*, 2005). In the wild, males leave the herd at sexual maturity and travel alone or with other similarly aged males. Females generally remain with their natal unit for the rest of their lives, living in matriarchal groups of 5 to 15 individuals. According to the Best Practices manual (2005), African savannah elephants should be housed in groups of at least ten adults, and African woodland and Asian elephants should be housed in groups of at lease five adults. Unfortunately, few zoos house this many elephants. Care of offspring is a central component of elephant society. In captivity, calves must not be separated from their mothers. Males should remain with their mothers until reaching sexual maturity (generally between the ages of 10 and 15) unless they begin to exhibit behavior, play or aggressive, that endangers the rest of the herd. Related females should not be separated from each other.

Institutions that choose to house adult male and female elephants must have separate facilities for the bulls, but should provide opportunities for mingling of the two sexes (Fig. 30). "Institutions holding both bulls and cows must approach their housing and social management with flexibility and must design their physical facilities to address contingencies and provide options" (*Best Practices by the Coalition for Captive Elephant Well-Being*, 2005). The aggression of some bulls will make them ineligible for interaction with females and calves. Institutions that do not house both sexes will often transport females to males for breeding purposes, but breeding success is infrequent among captive elephants.

For elephants new to the group, it is necessary to have facilities for all phases of the introduction process. Areas of isolation should adjoin elephant loading and unloading areas. The introduction process includes visual and olfactory contact only, limited tactile contact, greater tactile contact, and full physical contact with escape areas (*Best Practices by the Coalition for Captive Elephant Well-Being*, 2005) (Fig. 31).

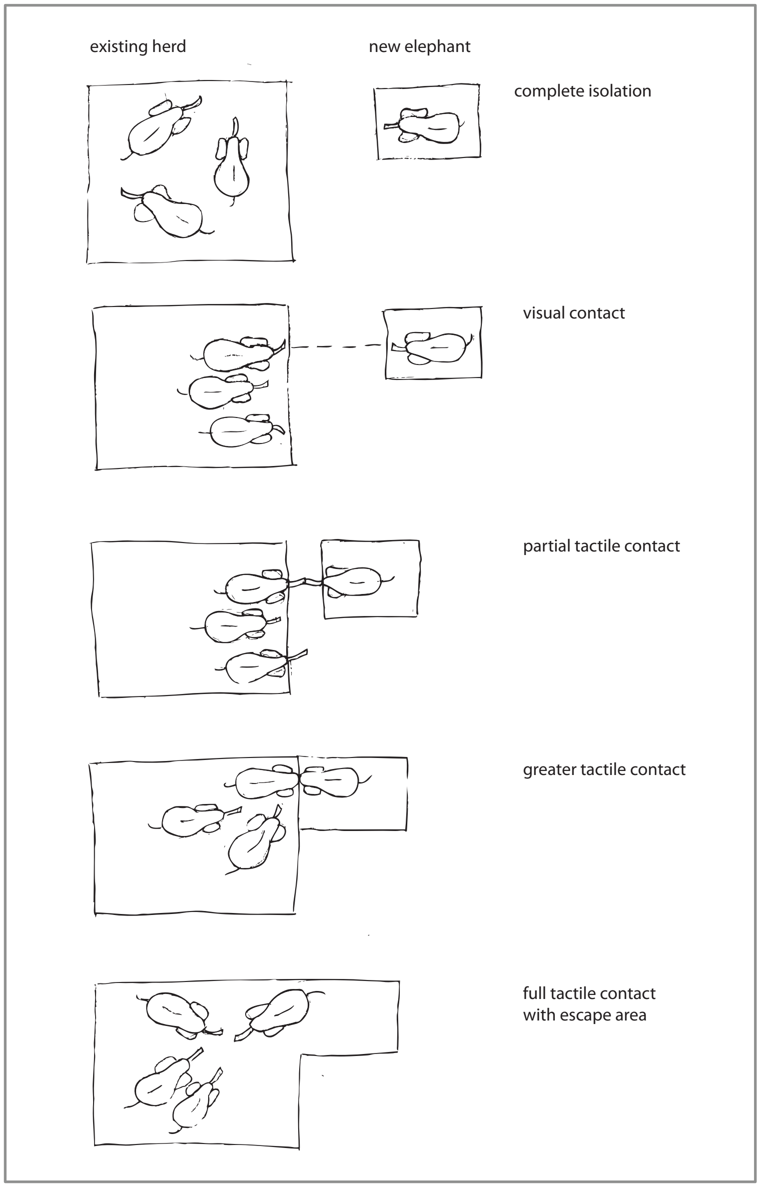

Figure 31. A new elephant should be introduced to the existing herd in phases.

In the wild, aggressive encounters between elephants usually end with the retreat of one of the animals, and it is important that captive environments offer enough space for this to occur. Design in the primary enclosure should allow freedom of contact between established group members, but should also provide circulation and minimize dead end spaces. To prevent entrapment, there should be no angles less than 90 degrees in the enclosure (*Best Practices by the Coalition for Captive Elephant Well-Being*, 2005). At all times, elephants must have areas of escape from other elephants and from public view.

Elephant quarters need to be designed to allow multiple housing options in case of disease or social incompatibilities. Sliding panels can allow for reconfiguration of the enclosure if animals need to be separated or isolated. Some zoos use large pillars as enclosure devices (Fig. 32). The space between the pillars is narrow enough that elephants cannot get through, but wide enough to provide keeper access, and the pillars can be moved to reconfigure the enclosure if necessary.

Figure 32. Pillars at the Copenhagen Zoo allow keepers to easily exit the elephant's enclosure. Photo by Lina Anhoff.

Any institution that houses elephants must be equipped with an elephant restraint device, which is necessary for providing medical care to the elephants. Areas must be designed that provide caretakers protected access to isolated, restrained elephants in order to carry out veterinary procedures. These spaces should allow caretakers access to all parts of the elephant's body while remaining out of trunk's reach, and they should include multiple exit points. Platforms are necessary to allow access to the higher parts of elephants, and foot holes are necessary to allow protracted access to elephants' feet (Figs. 33-34).

Figure 33. A keeper at the Belfast Zoo tends to an elephant's foot. Photo by Belfast Zoo.

Figure 34. In this design, multiple doors allow access to different parts of the elephant's body. Photo by A to Z Consulting.

Fencing and other enclosure elements must be able to withstand elephants' physical strength and curiosity. Pipe and cable fencing systems are suggested (Fig. 35). Ha-ha moat systems, with a perpendicular face on the outer edge of the enclosure and a 30 degree or less slope on the inside edge, are also acceptable (Fig. 36). Other dry-moat containment systems, particularly deep or narrow moats, are prohibited because they can be dangerous to elephants (*Best Practices by the Coalition for Captive Elephant Well-Being*, 2005) (Fig. 37).

Figure 35. Pipe and cable fencing is recommended for elephants, like Jenny at the Dallas Zoo. Photo by Donna McWilliam of Associated Press.

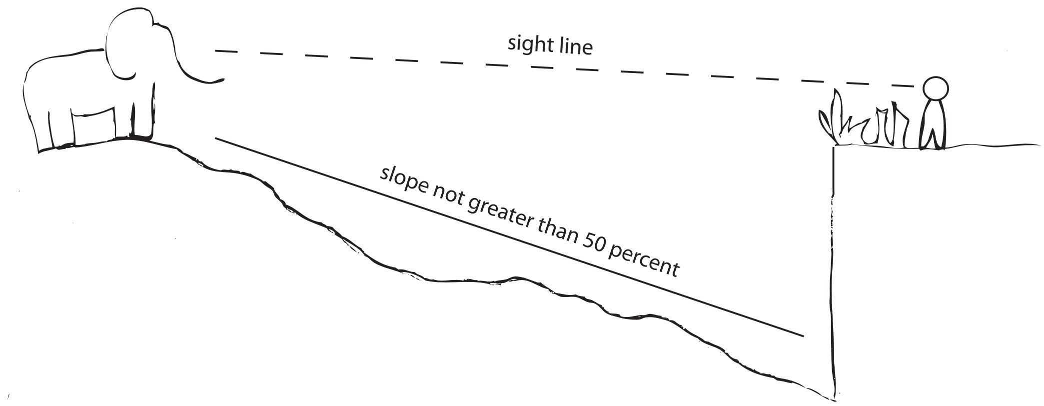

Figure 36. Ha-ha moat containment systems can also work for elephants.

Figure 37. This television screen shot shows an elephant stuck in a moat at the Milwaukee Zoo. Moat containment systems are not recommended for this reason. Image by WTMJ News.

Some general precautions to be taken when designing a space for elephants include ensuring that any electrical installations are inaccessible to them. Captive animals should not be exposed to toxic materials or fumes, such as paints, preservatives, or disinfectants. External noise (ventilation fans, traffic, people) should be kept to a minimum, with particular attention paid to minimizing low frequency noises to which elephants are particularly sensitive. Back up generators need to be available, and all areas of the habitat must be accessible by vehicle.

Elephant Enrichment Practices

This section will discuss enrichment practices for elephants, including those related to food, enclosure design, and interaction with humans and with other elephants.

In the wild, elephants spend 16 hours per day foraging for food – near continuous feeding. Their wild diet varies widely and includes herbs, creepers, leaves, twigs, bark, roots, reeds, flowers, and fruits (Stoinski, et al. 2000). Captive diets generally offer much less variety – simply adding new elements to the diet of captive elephants can be considered a method of enrichment (Figs. 38-40). New foods are particularly enriching if they require work to be enjoyed. *Browse* refers to the plants from which animals eat, and browse feeding requires animals to forage for their food. Browse feeding makes elephants work for their food and offers them an opportunity to engage in naturalistic behaviors (Fig. 41).

Figures 38-39. Elephants examine novel snacks – pumpkins! Photos by Association of Zoos and Aquariums.

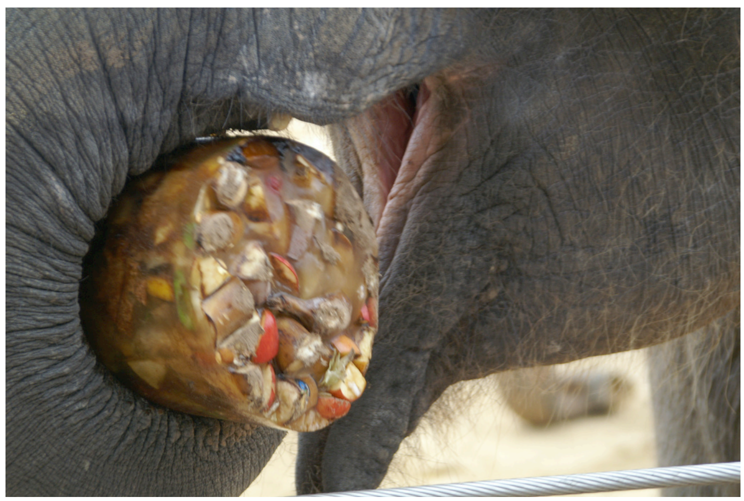

Figure 40. An elephant eats a frozen block of food items at the Twycross Zoo. Photo by Tim Ellis.

Figure 41. A truck full of browse arrives at the Oakland Zoo. The zoo has partnered with arborists so that tree trimmings from appropriate trees go to the elephants rather than the landfill. Photo by Green Alchemy.

Food may also be hidden from the elephants to encourage foraging. At the Royal Melbourne Zoological Gardens, keepers place food underwater and in trees while the elephants are in their nighttime quarters (Pennicuik, 2003). Other hiding possibilities include placing food over or under a wall, beneath substrate or other movable elements, or scattered throughout the enclosure (Fig. 42). More complex enrichment methods may utilize food-containing devices that must be opened, are almost out of reach, require multiple steps, involve tools, or necessitate teamwork (Figs. 43-44). Enrichment activities targeted at younger elephants should be made easier and less time consuming.

Figure 42. An elephant investigates a box of ginger-scented hay at the Twycross Zoo. Photo by Tim Ellis.

Figure 43. An elephant works to get hay from a moving contraption at the Hogle Zoo. Photo by Lisa Eller.

Figure 44. At the Denver Zoo, an elephant works to coax food from holes in a suspended ball. Similar enrichment toys have been made using beer kegs that roll on the ground. Toys for younger, less dexterous elephants should have more holes and/or larger holes. Photo via Wikimeida Commons.

In captivity, elephant diets are often spatially and temporally concentrated. It is enriching to provide food on irregular schedules and in irregular locations, as predictability can lead to boredom. However, there is evidence that, for elephants, providing food that takes longer to process is more enriching than providing temporally dispersed meals (Stoinski, 2000).

The shape of an enclosure can be just as important as the size of the enclosure. Transforming an open area into a number of defined spaces can create an environment that feels larger and is more stimulating. It is desirable to have multiple "destinations," such as pools, vista points, and rock features (Fig. 45). Designers should make as much of the available space as possible usable for the inhabitants.

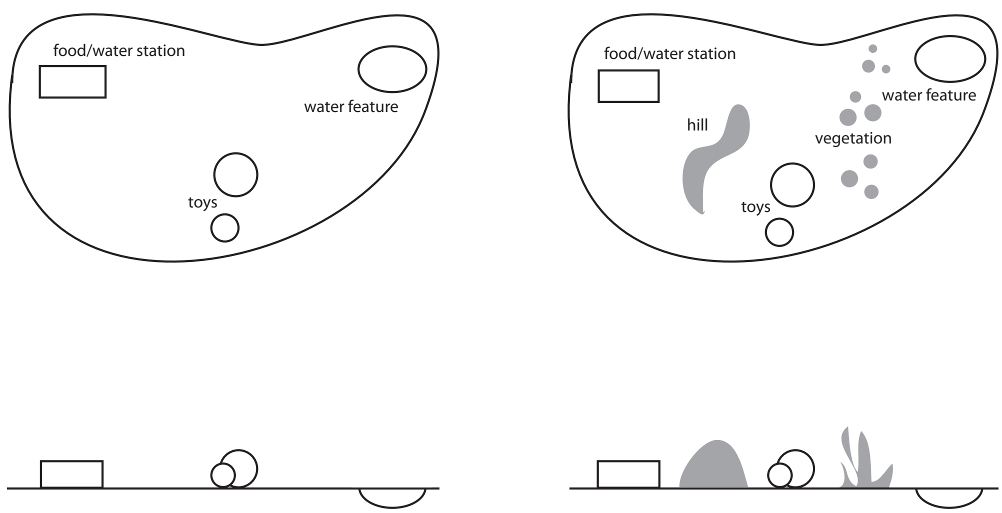

Figure 45. The plan and corresponding section on the right depict how landforms, vegetation, and amenity placement can be used to create different functional areas within an enclosure.

Outdoor areas should offer a variety of substrates, such as dirt, mulch, sand, and grass, as well as a variety of slopes and terrain, in order to encourage different types of physical activity. A full range of exercise should be encouraged and designed for, including: walking, running, turning, reaching, stretching, climbing, bending, digging, pushing, pulling, and lifting (*Best Practices by the Coalition for Captive Elephant Well-Being*, 2005). Plantings, particularly of vegetation that elephants will eat, are enriching. Zoos should be prepared to replace vegetation frequently, as elephants will quickly consume and/or trample it.

Bathing pools are very common enrichment amenities for elephants (Fig. 46). It may be more appropriate to consider them necessities than enrichments. When the Melbourne Zoo added a pool for its two elephants, they both immediately took to the water, despite not having swum for 25 years (Pennicuik, 2003). Not only do elephants love water, but pools are also an important means of providing them with low-impact exercise. Captive elephants frequently develop foot problems that can be life threatening. Such maladies are rare in the wild, and it is thought that captive elephants suffer these problems because they spend so much time on hard surfaces. Pools should be large enough to allow several adults to bathe simultaneously, and should have multiple exits so that elephants cannot trap each other in the pool (Fig. 47). These pools require high volume filtration systems (*Best Practices by the Coalition for Captive Elephant Well-Being*, 2005). Some zoos offer shower systems in addition to or instead of bathing pools. To keep bedding dry, water features should not be located near sleeping areas.

Figure 46. An elephant plays in the pool at the Taronga Zoo. Photo by Bradd Johnston.

Figure 47. The elephant pool at the San Diego Zoo offers multiple entrance and exit points. Photo by San Diego Zoo.

Mud and dust wallows are other enrichment amenities that elephants will use vigorously (Fig. 48). Rubbing surfaces are often positioned near wallows. Rocks, trees, tree stumps, and other large, sturdy objects can serve as rubbing surfaces (Fig. 49). They should be installed at varying heights.

Figure 48. An elephant takes a mud bath at the Chafee Zoo. Photo by Chaffee Zoo.

Figure 49. This tree has been used as a rubbing surface for multiple elephants. Photo by Susan Fox.

If possible, rubbing posts and other enrichment items should be rotated in, out, and throughout the exhibit to maximize stimulation. Other enrichment items that can be presented on a rotating basis might include tires, balls, logs, street sweeper brushes, and root balls (Figs. 50-51).

Figure 50. An elephant, Tange, plays with a tire at The Elephant Sanctuary in Tennessee. Photo by The Elephant Sanctuary.

Figure 51. A young elephant plays with a ball at the Orlando Zoo. Photo by Orlando Sentinel.

Interaction with humans can be enriching for elephants. An exhibit that would allow elephants to safely play tug of war with visitors would probably be enriching for both species. Training can serve as an enrichment method. Most beneficial is training that relies on positive reinforcement, which offers rewards for desired behavior and allows animals to cooperate voluntarily, rather than out of fear. Salivary cortisol levels (indicators of stress) are lower in elephants trained with positive reinforcement training than those trained with negative reinforcement, and animals trained this way require reduced use of anesthesia and restraint devices (Laule, 2003).

Probably most important to elephants is the ability to socialize. Elephants are gregarious animals that develop rich social networks. Relationships with each other are central to elephant life. In order to encourage the development of socially competent animals, captive elephants, particularly females, should be able to engage in self-directed social stimulation for the majority of their time. Feeding devices that require teamwork in order to acquire food and toys that allow for playful interactions are enrichment methods that can encourage social behavior (Fig. 52).

Figure 52. At the Thai Elephant Conservation Center, elephants work together for bowls of corn. With this device, the elephants must both pull the rope at the same time to move the bowls toward them. If just one elephant pulls, the rope will unravel. Photo by Discovery News.

Chapter 4 – Elephant Choices

"Why do 'we' always assume to know what's best for 'them,' even though these species have thrived for millions of years making their own choices?" (Coe, 1993). Might the lives of captive elephants be improved by offering them more choice and control in their environment?

Providing Choice

Simply increasing environmental complexity provides animals with greater choice and control by increasing the number of environmental options.

> In zoos, behavioural choices for animals are increased by enhancing the physical and temporal complexity of animals' surroundings, providing cognitive challenges and supplying specific environmental features that satisfy appetitive motivation. An animal with a large repertoire of behavioural options is more likely to be able to exert control over its environment because of the increased likelihood that it has learned contingencies between its environment and its behaviour (Carlstead and Shepherdson, 2000).

Natural landscapes are made up of overlapping environmental gradients, and animals meet their needs by moving through these gradients. Captive environments can be designed with gradients to offer their inhabitants more choices. For example, heating and cooling systems could be designed to offer areas of variable temperature. There are many other environmental parameters that can span gradients – scents, sounds, textures, terrain, enclosure, humidity, and light. The great ape facility at Chicago's Lincoln Park Zoo offers variable light levels based on a forest-like vertical gradient (Fig. 53).

Figure 53. The Lincoln Park Zoo offers different light levels throughout its great ape enclosure. Photo by Things You Should Do.

Ideally, captive habitats would resemble natural habitats in function as well as appearance. However, in many instances, “we have legally mandated that the complex interweaving of natural gradients be replaced with uniform light, temperature, and humidity standards. It is our homocentric bias to assume, without, question, that we know what is best.” (Coe, 1992).

If weather is reasonable, elephants could choose whether to sleep indoors or outside; they could be given a variety of bedding materials from which to choose. The Oakland zoo customizes the air temperature in each elephant’s stall, based on preferences exhibited by the animals.

> “It is impossible to release most zoo animals back into nature, but a useful method for improving their living conditions is by asking them what they prefer. Animals don’t speak our language but they can communicate with us … Research must be carried out to find out whether new enclosure innovations like glass instead of metal bars, paintings on

> walls, artificial flowers, and waterfalls make any difference for animals" (Wickins-Drazilova, 2005).

Animals can be offered preference or motivation tests to determine their desires. Generally, preference/motivation tests can be used to answer one of four questions:

> (1) whether an animal in motivated to obtain or avoid a resource; (2) whether it has a preference amongst alternative resources; (3) how strong its motivation or preference is; and (4) whether its preference, or the strength of its motivation or preference, is altered by changes in its internal or external environment (Kirkden and Pajor, 2006).

Preference tests can offer choices between two or more options. Motivation tests offer one or more options, with the extent to which the animal is willing to work for those options being indicative of the value they place on them. One study required pigs to press a lever for temperature modification or for access to earth for rooting. The number of times they were willing to press the level was considered indicative of the value they placed on the reward (Kirkden and Pajor, 2006). When comparing preference tests, the number or times a resource is chosen, the amount of time spent with it, or the quantity consumed are not necessarily good indicators of the value placed on that resource because different resources satiate at different rates. It is necessary to employ a measure that is independent of the magnitude of resource use (Kirkden and Pajor, 2006).

It should be noted that preference and motivation tests are dependent on context. For example, bedding preferences may change depending on the weather. The availability of one resource may affect the value an animal places on another resource. Preference tests are also dependent on experience; animals may initially prefer items/environments to which they are accustomed (Kirkden and Pajor, 2006). Preference tests are best conducted in a closed economy, with the options presented during the tests only available during the test period (Schapiro and Lambeth, 2007).

Another means of designing for increased choice and control is to give animals direct control over aspects of their environment. Elephants would be capable of managing light, temperature, humidity, background sounds, and other ambient parameters, within practical ranges (Coe, 1991). For example, elephants could be given showers or mist generators that they control. The technology that would enable this control is readily available and not very complicated. Dials, switches, and remote sensors are all potential methods. Automatic shut off after a period of time would be necessary for some elements.

Animals would need to be trained to operate new methods of control such as those discussed above. The process of training can be enriching for both elephants and humans.

> The humane and effective management of elephants in captivity is an expensive and complex challenge that requires ongoing institutional commitment. Elephants are highly intelligent, long-lived animals capable of learning a large repertoire of behaviors. Positive reinforcement based training is critical to provide them with mental and physical stimulation, gain their voluntary cooperation in husbandry and veterinary procedures, and promote their autonomy (Best Practices by the Coalition for Captive Elephant Well-Being, 2005).

Benefits of positive reinforcement training include increased mental stimulation, improved relationships between animals and caretakers, and greater choice and control over daily events (Laule, 2003).

Guidelines

Figure 54 depicts an elephant habitat designed in accordance with the ideas presented in this thesis. Table 2 offers design guidelines for the creation of an enriched elephant habitat that emphasizes choice and control. While many enrichment methods have been discussed in this paper, the guidelines focus on enrichment as it pertains to design.

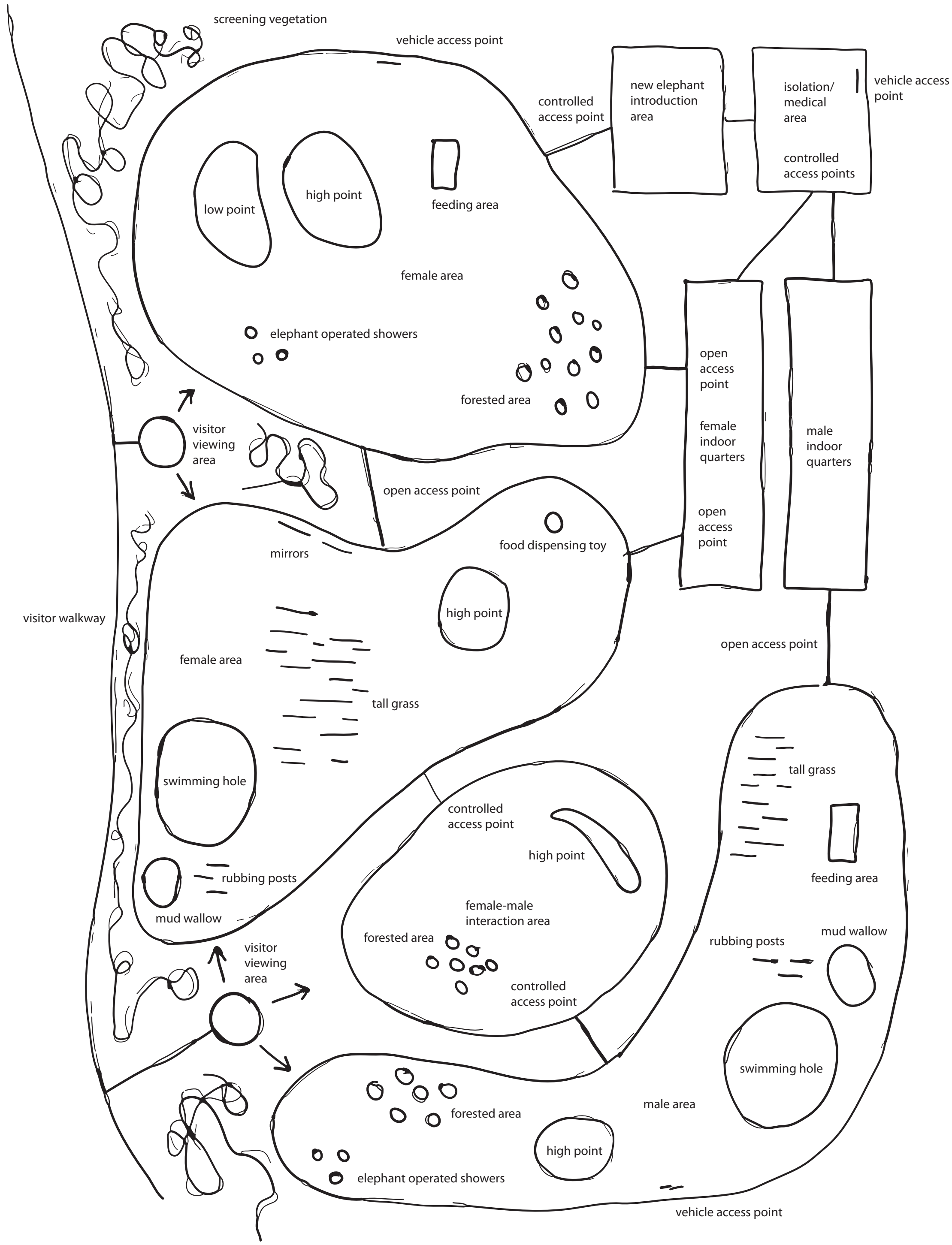

Figure 54. This habitat design would offer resident elephants an array of choices and adheres to the guidelines presented above.

Table 2. Listed below are general guidelines for the creation of an enriched habitat for captive elephants, with special attention to providing maximum choice and control.

Category	Indoor	Outdoor	Requirements	Choice/Control Options for Elephants
Space		X	Ability to be outdoors as much as possible – recommended that elephant habitats only be constructed in climates where temperature generally remains above 40 F	Choice of whether to be indoors or outdoors unless dangerous weather dictates otherwise; gradients in degree of enclosure to provide choices
		X	At least two sq km outdoor space per elephant	
	X		Overnight quarters – 60 sq m per female (with or without calf), 110 sq m per male	Choice of whether to be indoors or outdoors at night
	X		Winter quarters – 185 sq m per female (with or without calf), 370 sq m per male	Choice of whether to be indoors or outdoors during winter
Thermal	X		60-74 F indoor air temperature	Direct control over temperature within these parameters; gradients of temperature to provide choices
	X		Ventilation allowing for 4-5 changes of air every hour	Direct control over ventilation rate within these parameters
Light	X		As much natural light as possible	Gradients of light to provide choices; direct control over blinds or other light-blocking devices
	X		Full spectrum, tropical intensity artificial light	Direct control over light on/off as well as dimming/brightening (safety lighting exempt); gradients of light to provide choices
	X		Gradual dimming/brightening of light at night/morning	
	X	X	Nighttime light levels similar to star or moon light	
		X	At least 1/3 of outdoor habitat in shade at any given time	Direct control over shade structures that can be expanded or moved;

				gradients of light to provide choices
Flooring	X	X	Soft, non-slip flooring – ideally natural substrate like dirt or straw, but rubberized coating acceptable	Substrate variety and gradients to provide choices
	X		Soft, waterproof padding for sleep areas	Bedding variety to provide choices
Feeding	X	X	Flat, dry areas that can be cleaned regularly for food placement	Variety of feeding locations to provide choices
		X	Sturdy vegetation to allow for browse feeding – will require regular replanting	Vegetation variety to provide choices
	X	X	Toys/puzzles that offer food as a reward	Toy variety to provide choices
Landscape		X	Landscape divided into different functional areas	Variety of “destinations” to provide choices; direct control over landscape elements to allow customization of space (e.g., sliding panels)
		X	Variations in terrain	Terrain variety and gradients to provide choices
		X	Vegetation – must be non-toxic to elephants and will require regular replanting	Vegetation variety and gradients to provide choices
Amenities		X	Pools – require high volume filtration systems	Temperature gradients or warm/cool spots to provide choices
		X	Showers	Direct control of on/off (automatic shut off after period of time); direct control of temperature (within set parameters)
		X	Mud/dust wallows	Direct control of water source to make muddy (automatic shutoff after period of time)
		X	Rubbing surfaces	Variety of surfaces to provide choices
	X	X	Fans	Direct control of on/off and velocity

	X	X	Toy objects/structures	Toy variety to provide choices
Social	X	X	Elephants housed in groups of no fewer than 5 individuals – at least 10 is preferable	Areas of isolation to provide choices
	X	X	Males and females housed separately (young males remain with mother until maturity)	
		X	Design to allow for controlled interaction between the sexes	Areas of isolation to provide choices
	X	X	Design to allow for gradual introduction of new elephants	Areas of isolation to provide choices
	X	X	Maximize circulation, minimize dead end spaces	
Enclosure		X	Pipe and cable or ha-ha moat systems (no greater than 30 degree slope) for main enclosure	
	X	X	Flexible space deign to accommodate social incompatibility or disease – sliding panels or removable pillars	
	X		Elephant restraint area for medical care	
Safety	X	X	Electrical installations inaccessible	
	X	X	Minimize exposure to noise pollution, particularly low frequency noises	
	X	X	Backup generators	
	X	X	All areas accessible by vehicle	

Challenges

With increased freedom come increased risks. New opportunities for movement and exploration increase the likelihood of injury. Opportunities for socialization increase risks of disease and conflict. New foods present the risk of toxic or allergic reactions. With any enrichment effort, risks must be assessed and use must be monitored.

Preference tests were discussed as a means of determining animals' preferences in their environment. Such tests have been criticized for the fact that they provide only relative information. Abbleby argues, however, that "Relative information is the only sort of information that is possible: there are no worst or best possible designs" (1997). Preference tests are useful because many aspects of welfare can only be assessed in a relative sense. However, preference tests alone cannot be used to determine appropriate facility design and care because animals (including people) do not always make optimal choices regarding their welfare. In the late 1800s, some zoos fed their primates fruit-only diets due to the primates' demonstrated preferences, and many died of diarrhea (Abbleby, 1997).

Perhaps the biggest challenge in giving captive animals more choices control is that it will require a rethinking of the relationship between humans and captive animals. It is necessary to acknowledge that these animals may be capable of managing more of their care than they have ever been allowed.

Conclusion

This thesis brought together many different pieces of research on environmental enrichment. As is the nature of scientific research, most cases are highly specific. In this paper, the results of these numerous studies were combined and generalized to form one set of guidelines for the creation of an enriched environment for captive elephants.

As was hypothesized, there are design interventions that can offer captive elephants greater choice and control in their environments. Research suggests that these interventions would alleviate some of the stress that accompanies life in captivity: in general, more choices and control lead to reduced stress levels. Use of the guidelines presented here should improve the lives of captive elephants.

However, it is necessary to test enrichment methods to ensure that they are having the intended consequences. Does offering captive elephants a shower improve their lives? Does making the shower something that they turn on and off, rather than something operated by a zookeeper, make their lives even better? Existing research suggests that these actions would improve the elephants' quality of life. But questions like these have not been directly answered. More studies need to be conducted.

Enrichment programs should include plans for how results will be measured. Zoos and designers may want to consider partnering with academic institutions to study the effects of their enrichment programs.

Few preference tests have been conducted with elephants, or with other captive animals. If offering captive animals with greater choice and control is the future of environmental enrichment, it would be good to start asking the animals what they'd like.

The design guidance presented in this thesis is the first of its kind. It is the first set of brief guidelines for the creation of enriched habitats for elephants. It is also the first set of guidelines that emphasize how to give the inhabitants as much control as possible. These guidelines are intended to assist designers as they begin the process of creating a space for captive elephants.

Ideally, such guidance would exist for all species held in captivity. Creation of such guidelines does not need to fall on one individual or institution. An online repository would enable such guidelines to be created, shared, and improved upon by all those in the field of zoo design. There is currently no single go-to place for practitioners to share stories of enrichment success and failure. This online resource could be searchable by species and enrichment activity. A single place for those designing for and working with zoo animals to share their experiences would be a highly valuable tool.

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