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# Role of Zoological Parks in Ex-Situ Conservation of Threatened Wildlife Species: Biodiversity Preservation outside Natural Habitats

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**ABSTRACT:** Zoological parks have evolved from traditional animal exhibition centers into important institutions for wildlife conservation, environmental education, and public awareness. In the context of increasing biodiversity loss and ecological degradation, zoos play a significant role in promoting conservation ethics among visitors through structured educational programs, interpretive displays, and interactive learning initiatives. This study examines the educational and awareness functions of zoological parks in fostering public understanding of wildlife conservation. The research focuses on how educational activities, visitor engagement, and informational resources contribute to shaping positive attitudes toward biodiversity protection. Using a descriptive research approach based on secondary sources and visitor perception analysis, the study evaluates the effectiveness of zoo-based educational strategies. The findings suggest that zoological parks significantly influence visitor knowledge, environmental awareness, and pro-conservation attitudes. Strengthening educational programs and participatory learning experiences in zoos can further enhance their role as key institutions in promoting sustainable wildlife conservation and responsible environmental behavior.

**KEYWORDS:** Wildlife Conservation, Zoological Parks, Environmental Education, Conservation Awareness, Visitor Perception, Biodiversity Protection.

## I. INTRODUCTION

### Global Biodiversity Crisis and Extinction Risk

The global decline of biodiversity has become one of the most pressing environmental challenges of the twenty-first century. Rapid industrialization, deforestation, habitat fragmentation, climate change, and illegal wildlife trade have significantly accelerated the extinction rate of numerous animal species worldwide. According to the assessments conducted by the International Union for Conservation of Nature, thousands of species are currently categorized as vulnerable, endangered, or critically endangered in the global Red List database. Scientific studies indicate that the present rate of species extinction is several times higher than natural background extinction levels, highlighting the severity of biodiversity loss (Pimm et al., 2014). The disappearance of wildlife species not only disrupts ecological balance but also affects ecosystem services essential for human survival, including pollination, nutrient cycling, and climate regulation (Dirzo et al., 2014). Consequently, the conservation of threatened wildlife species has become a global priority for environmental scientists, conservationists, and policymakers. Addressing biodiversity loss requires comprehensive conservation strategies that integrate ecological research, habitat protection, and species management programs across both natural and controlled environments.

### Importance of Conservation Biology

Conservation biology has emerged as an interdisciplinary scientific field dedicated to understanding and mitigating biodiversity loss through scientific research, ecological management, and conservation planning. The discipline integrates knowledge from zoology, ecology, genetics, and environmental science to develop effective strategies for preserving species and ecosystems (Primack, 2014). Conservation biology emphasizes the protection of endangered species, restoration of degraded habitats, and maintenance of ecological balance within natural ecosystems. In recent decades, conservation scientists have recognized that preserving wildlife solely in natural habitats may not always be sufficient due to increasing anthropogenic pressures such as habitat destruction and climate change (Soulé, 1985). Therefore, complementary conservation approaches have been developed to safeguard species that face immediate extinction threats. These strategies include habitat restoration, wildlife corridors, genetic management, and captive



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breeding initiatives. By combining scientific research with practical conservation measures, conservation biology provides a systematic framework for protecting biodiversity and ensuring the long-term survival of threatened wildlife populations across diverse ecological landscapes.

### In-situ and Ex-situ Conservation Approaches

Wildlife conservation strategies are broadly categorized into in-situ and ex-situ conservation approaches. In-situ conservation focuses on protecting species within their natural habitats by establishing protected areas such as national parks, wildlife sanctuaries, and biosphere reserves. This approach allows species to evolve naturally within their ecological environments while maintaining complex ecosystem interactions (Hunter & Gibbs, 2007). However, increasing habitat degradation and human encroachment have limited the effectiveness of in-situ conservation for many highly threatened species. In contrast, ex-situ conservation involves the preservation of species outside their natural habitats under controlled conditions, such as zoological parks, wildlife breeding centers, aquariums, and botanical gardens. Ex-situ conservation enables scientists to maintain viable populations of endangered species, conduct genetic research, and develop breeding programs aimed at species recovery (Frankham et al., 2010). Both approaches are considered complementary rather than mutually exclusive. When integrated effectively, in-situ and ex-situ conservation strategies provide a comprehensive framework for biodiversity protection and wildlife management in the face of escalating environmental challenges.

### Emergence of Modern Zoological Parks as Conservation Institutions

Historically, zoological parks were primarily designed for recreation and public entertainment, displaying exotic animals for educational and aesthetic purposes. However, during the late twentieth century, the role of zoological parks gradually transformed from exhibition centers to scientific institutions dedicated to wildlife conservation, research, and environmental education. Modern zoological parks now participate actively in global conservation initiatives, including captive breeding, genetic management, and wildlife rehabilitation programs (Hutchins & Conway, 1995). These institutions provide controlled environments where threatened species can be protected from immediate threats such as poaching, habitat loss, and disease outbreaks. In addition to conservation breeding, zoos also contribute to veterinary research, behavioral studies, and ecological monitoring that support wildlife management strategies. Contemporary zoological parks collaborate with conservation organizations, universities, and governmental agencies to implement coordinated conservation programs. As a result, they have become essential components of global biodiversity conservation frameworks aimed at preventing species extinction and promoting sustainable wildlife management practices.

### Role of Global and National Conservation Organizations

The conservation efforts of zoological parks are often guided and supported by international and national conservation organizations that establish policies, guidelines, and collaborative research initiatives. The World Association of Zoos and Aquariums play a significant role in coordinating conservation programs among zoological institutions worldwide, promoting ethical animal management, and encouraging collaborative breeding programs across different countries. Similarly, in India, the Central Zoo Authority regulates the functioning of zoological parks and ensures that they adhere to standardized guidelines related to animal welfare, breeding programs, and conservation education. These organizations facilitate knowledge exchange, research collaboration, and resource sharing among zoological parks, thereby strengthening global conservation efforts. Through structured frameworks such as species survival plans, genetic management databases, and international breeding programs, these institutions help maintain sustainable populations of endangered species and promote coordinated conservation strategies across national boundaries (Fa et al., 2014).

### Importance of Captive Breeding and Species Recovery Programs

Captive breeding programs represent one of the most significant contributions of zoological parks to ex-situ conservation. These programs involve the controlled reproduction of endangered species within zoological institutions to increase population numbers and preserve genetic diversity (Conway, 2011). By maintaining carefully managed breeding populations, zoos can prevent the immediate extinction of species whose wild populations have declined dramatically due to habitat destruction, illegal hunting, or environmental changes. Captive breeding initiatives have successfully contributed to the recovery of several threatened species, including various mammals, birds, and reptiles. In addition to breeding programs, zoological parks also support species recovery through rehabilitation centers, veterinary care, and reintroduction initiatives that aim to restore populations in their natural habitats. These programs require advanced scientific knowledge in genetics, reproductive biology, and animal behavior to ensure the long-term



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viability of captive populations. Consequently, zoological parks have become essential partners in global conservation networks dedicated to safeguarding biodiversity and restoring endangered wildlife populations.

### Research Gap and Significance of the Study

Despite the growing recognition of zoological parks as conservation institutions, debates continue regarding their overall effectiveness in protecting biodiversity and supporting species recovery programs. While numerous studies emphasize the conservation potential of zoological parks, others raise concerns about ethical issues, genetic limitations of captive populations, and the challenges associated with reintroducing captive-bred animals into the wild (Jamieson, 2010). Furthermore, many existing studies focus primarily on the management or educational functions of zoological parks rather than evaluating their broader contribution to ex-situ biodiversity conservation. This creates a research gap in understanding the comprehensive role of zoological parks in preserving threatened wildlife species outside natural habitats. Therefore, the present study aims to examine the conservation functions of zoological parks within the framework of ex-situ conservation strategies. By analyzing conservation initiatives, breeding programs, and research contributions of zoological institutions, the study seeks to highlight their significance in global biodiversity preservation and provide insights for strengthening future conservation efforts.



FIGURE 1: FRAMEWORK OF EX-SITU CONSERVATION STRATEGIES IN ZOOLOGICAL PARKS

### Interpretation

The framework illustrates the sequential conservation process implemented in zoological parks for protecting threatened wildlife species. Beginning with rescue and rehabilitation, the process progresses through captive breeding and genetic management to scientific research and reintroduction programs. This integrated strategy enables zoological institutions to contribute significantly to long-term biodiversity conservation outside natural habitats.

## II. REVIEW OF LITERATURE

### Development of Zoological Parks as Conservation Institutions

The role of zoological parks has evolved considerably over the past century. Early zoological parks were primarily established for recreational and exhibition purposes, where animals were displayed for public entertainment. However, the growing awareness of biodiversity loss and the increasing number of threatened species have significantly transformed the functions of modern zoos. Contemporary zoological institutions now serve as centers for wildlife conservation, scientific research, education, and species recovery programs (Hutchins & Conway, 1995). According to



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Conway (2011), modern zoos have shifted their focus toward conservation-oriented management strategies that emphasize breeding endangered species, maintaining genetic diversity, and supporting habitat conservation initiatives. This transition reflects a broader recognition within conservation biology that zoological parks can play a vital role in safeguarding species that face extinction in the wild. Researchers also emphasize that well-managed zoos contribute to long-term biodiversity preservation by maintaining viable populations of rare and endangered species under controlled conditions, thereby supporting global conservation efforts (Fa et al., 2014).

### Role of Zoological Parks in Ex-situ Conservation

Ex-situ conservation refers to the preservation of species outside their natural habitats through controlled management systems such as zoological parks, wildlife breeding centers, and botanical gardens. Scholars have widely recognized ex-situ conservation as an important complementary approach to in-situ conservation strategies. According to Frankham, Ballou, and Briscoe (2010), ex-situ conservation enables scientists to protect endangered species that cannot survive in degraded natural habitats due to factors such as habitat destruction, climate change, and human interference. Zoological parks provide a controlled environment where species can be protected from immediate threats while their populations are stabilized through breeding and genetic management programs. Furthermore, ex-situ conservation facilities allow researchers to conduct studies on animal behavior, reproduction, and disease management, which are essential for developing effective conservation strategies. Hutchins (2003) argues that zoological parks play a critical role in maintaining “insurance populations” of endangered species, ensuring their survival even if wild populations decline dramatically. Consequently, zoological parks have become integral components of modern conservation frameworks aimed at preventing species extinction.

### Captive Breeding Programs and Species Recovery

Captive breeding programs represent one of the most important contributions of zoological parks to wildlife conservation. These programs involve controlled reproduction of endangered species with the objective of increasing their population size and preserving genetic diversity. Research indicates that captive breeding initiatives have contributed significantly to the recovery of several endangered species, including mammals, birds, reptiles, and amphibians (Conway, 2011). According to Snyder et al. (1996), captive breeding programs can serve as a temporary conservation strategy when natural habitats are severely degraded or when wild populations are critically low. Successful breeding programs require careful management of genetic diversity to prevent inbreeding and maintain healthy populations. Modern zoological parks utilize advanced reproductive technologies, pedigree analysis, and genetic databases to manage breeding populations effectively (Frankham et al., 2010). In addition to population growth, captive breeding programs also support reintroduction initiatives that aim to restore species populations in their natural habitats. As a result, zoological parks have become important partners in global conservation networks dedicated to species recovery and biodiversity protection.

### Contribution of Zoos to Scientific Research and Wildlife Management

Another important aspect highlighted in the literature is the contribution of zoological parks to scientific research and wildlife management. Zoos provide valuable opportunities for researchers to study animal physiology, reproductive biology, nutrition, behavior, and disease control in controlled environments. Such research is essential for developing conservation strategies for endangered species both in captivity and in the wild (Barongi, Fischen, Parker, & Gusset, 2015). According to Fa, Funk, and O’Connell (2014), zoological institutions have increasingly become centers for conservation research, collaborating with universities and wildlife organizations to conduct ecological and veterinary studies. These research activities contribute to a better understanding of species ecology and enable the development of effective management strategies for threatened wildlife populations. Additionally, zoological parks often serve as rescue and rehabilitation centers for injured or confiscated wildlife, providing veterinary care and facilitating their recovery. This combination of research, rehabilitation, and conservation management demonstrates the growing importance of zoological parks in supporting global biodiversity conservation initiatives.

### Educational and Public Awareness Functions of Zoological Parks

The literature also emphasizes the role of zoological parks in promoting environmental education and raising public awareness about wildlife conservation. Educational programs conducted by zoos aim to inform visitors about biodiversity loss, endangered species, and the importance of protecting natural ecosystems. According to Moss, Jensen, and Gusset (2015), zoo visitors often develop stronger conservation attitudes and environmental awareness after participating in educational exhibits and interactive programs. Zoos provide unique opportunities for people to observe wildlife closely, which can foster emotional connections with animals and encourage pro-conservation behavior.



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Educational campaigns organized by zoological parks frequently include guided tours, conservation workshops, and outreach programs designed to engage communities in biodiversity protection efforts. Furthermore, zoos collaborate with schools, universities, and environmental organizations to promote conservation education among younger generations. Through these initiatives, zoological parks contribute not only to species preservation but also to the development of public support for wildlife conservation policies and sustainable environmental practices.

### Ethical Concerns and Limitations of Zoo-based Conservation

Despite the recognized contributions of zoological parks to conservation, several scholars have raised concerns regarding the ethical and practical limitations of zoo-based conservation strategies. Critics argue that keeping animals in captivity may restrict their natural behaviors and reduce their ability to adapt to wild environments (Jamieson, 2010). Additionally, maintaining genetically viable populations in captivity can be challenging due to limited population sizes and the risk of inbreeding (Frankham et al., 2010). Some researchers also question the effectiveness of reintroducing captive-bred animals into natural habitats, as these animals may lack the survival skills necessary for life in the wild. Nevertheless, proponents of zoo-based conservation argue that when properly managed, zoological parks can provide safe environments for endangered species and support long-term conservation programs (Barongi et al., 2015). Modern zoos increasingly adopt enrichment programs, naturalistic enclosures, and scientific breeding strategies to improve animal welfare and conservation outcomes. Therefore, while challenges exist, zoological parks continue to play a significant role in supporting global conservation efforts.

**TABLE 1: SUMMARY OF MAJOR STUDIES ON ZOOLOGICAL PARKS AND WILDLIFE CONSERVATION**

Author(s)	Year	Focus of Study	Key Findings
Hutchins & Conway	1995	Evolution of modern zoos and conservation role	Modern zoological parks have shifted from exhibition centers to conservation institutions involved in species management and biodiversity protection.
Snyder et al.	1996	Captive breeding and species recovery	Captive breeding programs can prevent extinction of endangered species when natural populations decline, though long-term habitat protection remains essential.
Hutchins	2003	Role of zoos in wildlife conservation and education	Zoological parks contribute to conservation through research, public education, and breeding programs for threatened wildlife species.
Conway	2011	Conservation-oriented zoo management	Zoos play an important role in maintaining genetic diversity and supporting global species recovery initiatives.
Fa, Funk, & O'Connell	2014	Zoos and global biodiversity conservation	Zoological institutions support conservation research, captive breeding, and environmental awareness programs that contribute to biodiversity preservation.

Source: Author's compilation based on published literature on zoological parks and wildlife conservation.

### Interpretation

The table summarizes key scholarly studies highlighting the evolving role of zoological parks in wildlife conservation. Earlier research emphasized the transformation of zoos from exhibition facilities to conservation institutions. More recent studies highlight their contributions to captive breeding, scientific research, and biodiversity education, demonstrating their increasing importance in global conservation strategies.

## III. RESEARCH METHODOLOGY

### Research Design

The present study adopts a qualitative and descriptive research design to examine the role of zoological parks in the ex-situ conservation of threatened wildlife species. This approach is appropriate because the research focuses on analyzing conservation practices, institutional roles, and management strategies implemented by zoological parks for biodiversity preservation. Qualitative research allows for a comprehensive understanding of conservation mechanisms, including captive breeding, species recovery programs, wildlife rehabilitation, and scientific research activities conducted by



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zoological institutions. Descriptive analysis is used to interpret existing conservation practices and evaluate their contribution to biodiversity protection outside natural habitats. The study emphasizes conceptual and analytical examination rather than experimental investigation, making it suitable for assessing conservation frameworks and institutional initiatives. Previous conservation research has also relied on descriptive and qualitative methodologies to analyze wildlife conservation policies and zoo-based conservation programs (Frankham et al., 2010; Barongi et al., 2015). Therefore, the research design adopted in this study provides a systematic framework for understanding how zoological parks contribute to global conservation efforts.

### Sources of Data

The research is primarily based on secondary data sources, which are widely used in conservation studies and biodiversity research. Relevant information has been collected from academic journals, scientific books, conservation reports, and publications related to wildlife management and zoological park administration. Reports and policy documents published by international and national conservation organizations have also been used to support the analysis. Key conservation organizations such as the International Union for Conservation of Nature and the World Association of Zoos and Aquariums provide valuable data regarding endangered species, conservation strategies, and zoo-based breeding programs. In the Indian context, policy guidelines and conservation initiatives implemented by the Central Zoo Authority have also been reviewed. The use of secondary data enables the study to analyze existing conservation programs and evaluate their effectiveness in preserving threatened species outside natural habitats. By examining multiple scholarly and institutional sources, the study ensures reliability and credibility in the interpretation of conservation practices.

### Method of Data Analysis

The collected data have been analyzed using comparative and thematic analysis techniques. Comparative analysis is used to examine different conservation initiatives undertaken by zoological parks, including captive breeding programs, wildlife rehabilitation centers, and research activities related to endangered species. Thematic analysis helps in identifying key patterns and themes within the literature, such as biodiversity conservation, genetic management, species recovery programs, and environmental education. These analytical methods allow the researcher to synthesize information from multiple sources and develop a comprehensive understanding of the conservation roles performed by zoological parks. In addition, case-based analysis of selected zoological institutions provides practical insights into how conservation strategies are implemented in real-world settings. The integration of comparative and thematic approaches ensures that the study provides both conceptual understanding and practical perspectives regarding ex-situ conservation practices.

### Scope of the Study

The scope of the study is limited to examining the conservation role of zoological parks within the framework of ex-situ wildlife conservation. The research focuses on conservation initiatives implemented by selected zoological institutions and conservation networks that contribute to biodiversity preservation. Examples of prominent zoological parks such as National Zoological Park, San Diego Zoo, and London Zoo provide illustrative cases of conservation practices including captive breeding, wildlife research, and species recovery programs. The study also considers international conservation frameworks and policies guiding zoo-based conservation efforts. However, the research does not include primary field surveys or experimental data collection. Instead, it focuses on analytical evaluation of existing literature and documented conservation initiatives. This scope enables the study to present a comprehensive overview of the contribution of zoological parks to biodiversity conservation outside natural habitats while highlighting their role in global wildlife preservation strategies.

## IV. RESULTS AND DISCUSSION

### Contribution of Zoological Parks to Ex-situ Conservation

The analysis of existing literature and conservation reports indicates that zoological parks play a significant role in the ex-situ conservation of threatened wildlife species. Modern zoological institutions have evolved beyond their traditional roles of animal exhibition and entertainment to become active participants in global conservation initiatives. Through carefully designed management programs, zoological parks provide safe environments where endangered species can be protected from threats such as habitat destruction, poaching, and climate change. Conservation organizations such as the International Union for Conservation of Nature emphasize the importance of integrating ex-situ conservation strategies with broader biodiversity protection frameworks. Zoological parks maintain controlled



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habitats that allow scientists and conservationists to monitor species health, reproduction, and behavior under stable conditions. These controlled environments enable conservation professionals to maintain viable populations of endangered species while developing strategies for their long-term survival. Consequently, zoological parks serve as essential conservation institutions that complement in-situ conservation efforts in natural ecosystems.

### Captive Breeding and Genetic Management

One of the most important conservation functions of zoological parks is the implementation of captive breeding programs aimed at increasing the population size of endangered species. Captive breeding programs allow zoological institutions to maintain genetically diverse populations of species that may have declined or fragmented populations in the wild. Research findings suggest that well-managed breeding programs contribute significantly to species recovery and genetic stability (Frankham et al., 2010). International conservation networks coordinated by organizations such as the World Association of Zoos and Aquariums facilitate collaboration among zoological parks by sharing breeding data, genetic records, and management strategies. This collaborative approach helps prevent inbreeding and ensures the maintenance of healthy captive populations. In addition to population growth, captive breeding programs support reintroduction initiatives that aim to restore species populations in their natural habitats. Successful breeding programs require scientific expertise in genetics, reproductive biology, and animal husbandry, demonstrating the growing importance of zoological parks as centers of conservation science and wildlife management.

### Wildlife Rehabilitation and Scientific Research

Another important outcome highlighted in the analysis is the role of zoological parks in wildlife rehabilitation and scientific research. Many zoological institutions operate rescue and rehabilitation centers that provide medical care and treatment for injured, confiscated, or orphaned wildlife. These facilities help restore the health of animals before releasing them back into suitable natural environments whenever possible. In addition, zoological parks provide valuable opportunities for scientific research on animal behavior, nutrition, disease control, and reproductive biology. Such research contributes to improved management practices for both captive and wild populations of threatened species (Barongi et al., 2015). The development of veterinary science within zoological parks has significantly enhanced animal health monitoring and disease prevention strategies. These research activities also support conservation planning by providing scientific knowledge necessary for species recovery programs. As a result, zoological parks function not only as conservation centers but also as research institutions that generate valuable knowledge for wildlife management and biodiversity preservation.

### Public Education and Conservation Awareness

The results also highlight the important role of zoological parks in environmental education and public awareness regarding biodiversity conservation. Educational programs organized by zoological parks aim to inform visitors about endangered species, ecosystem protection, and the importance of sustainable environmental practices. Studies indicate that visitors who participate in zoo-based educational activities often develop stronger conservation attitudes and greater awareness of biodiversity issues (Moss et al., 2015). Through exhibitions, guided tours, and conservation campaigns, zoological parks provide opportunities for the public to learn about wildlife and the threats faced by endangered species. These educational initiatives encourage individuals to support conservation policies and participate in environmental protection efforts. Furthermore, zoos frequently collaborate with schools, universities, and conservation organizations to promote environmental education among younger generations. By combining conservation education with scientific research and breeding programs, zoological parks contribute to long-term biodiversity protection and the development of public support for wildlife conservation initiatives.

TABLE 2: CONSERVATION CONTRIBUTIONS OF ZOOLOGICAL PARKS

Conservation Activity	Description	Contribution to Biodiversity Conservation
Captive Breeding Programs	Controlled breeding of endangered species in zoological parks	Helps increase population size and prevents extinction of threatened species
Genetic Management	Monitoring and maintaining genetic diversity among captive populations	Reduces inbreeding and ensures long-term survival of species



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Conservation Activity	Description	Contribution to Biodiversity Conservation
Wildlife Rehabilitation	Rescue, medical treatment, and recovery of injured or confiscated wildlife	Supports restoration of wildlife populations and improves survival chances
Scientific Research	Studies on animal behavior, reproduction, nutrition, and disease control	Provides scientific knowledge necessary for wildlife management and conservation
Environmental Education	Educational programs and conservation awareness campaigns for visitors	Encourages public participation and support for biodiversity conservation

Source: Author’s compilation based on wildlife conservation literature.

### Interpretation

The table highlights the key conservation functions performed by zoological parks. Captive breeding and genetic management programs help maintain viable populations of endangered species, while rehabilitation centers assist injured wildlife. Additionally, research and environmental education initiatives conducted by zoos contribute to broader biodiversity conservation and promote public awareness about wildlife protection.



**FIGURE 2: ROLE OF ZOOLOGICAL PARKS IN BIODIVERSITY CONSERVATION**

### Interpretation

The figure illustrates the integrated role of zoological parks in biodiversity conservation. Through scientific research, captive breeding, and species recovery initiatives, zoological institutions contribute to the preservation of endangered wildlife. Reintroduction programs and educational activities further strengthen conservation efforts by restoring species populations and increasing public awareness about environmental protection.

## V. CONCLUSION

Zoological parks play a crucial role in the ex-situ conservation of threatened wildlife species and contribute significantly to global biodiversity preservation. Modern zoos have evolved from traditional animal exhibition centers into scientific institutions that actively participate in conservation breeding, wildlife research, rehabilitation, and environmental education. Through well-managed captive breeding and genetic management programs, zoological parks



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help maintain viable populations of endangered species that are at risk of extinction in the wild. International conservation bodies such as the International Union for Conservation of Nature and the World Association of Zoos and Aquariums further support collaborative conservation initiatives among zoological institutions worldwide. In addition, zoos play an important role in raising public awareness about biodiversity protection and environmental sustainability. Although challenges such as ethical concerns and habitat limitations remain, well-regulated zoological parks continue to serve as essential partners in global conservation strategies aimed at safeguarding endangered wildlife species for future generations.

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