

Review

Understanding How the Unique Context of the Minnesota Zoo Shapes Our Local Conservation Initiatives

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Abstract: The field of wildlife conservation is comprised of a variety of players with different contexts and approaches. Zoos and aquariums, historically largely focused on public entertainment, are shifting more towards conservation-minded missions and can play a unique role in wildlife conservation by leveraging their distinct assets. The Minnesota Zoo is an AZA-accredited institution and an agency of the State of Minnesota that has been conducting wildlife conservation for over 40 years. Here, we review our current portfolio of local field projects, including initiatives targeting pollinators, native mussels, turtles, and bison, using several considerations to structure and better understand how our unique context has shaped our work. Our designation as a state agency has impacted our initiatives by necessitating a focus on local efforts and has facilitated many partnerships with other government agencies. Indeed, partnerships have been vital to our success and have shaped our programs significantly since their inception. All of the Zoo's conservation initiatives are built on a bedrock of sound science, and we continue to contribute to the field through research, utilizing the expertise of department staff. In addition, the various funding streams that support our programs have dramatically shaped our work and have created some siloing of staff within the department. However, grant funding can serve as a buffer against the impacts of economic uncertainty, as evidenced during the COVID-19 pandemic. Lastly, our programs have expanded and our objectives have pivoted over the years in response to changing needs and opportunities; such flexibility—and increased flexibility for our staff—is imperative to the future success of these efforts. The Minnesota Zoo's narrative is unique and helps us understand how we can continue to most effectively carry out local conservation efforts. As we work to protect habitats and save species from extinction, it is important to utilize the distinct assets that each organization can contribute in order to have the greatest collective impact.

Keywords: bison; butterfly; ex situ conservation; government agency; in situ conservation; native mussels; turtles; zoos and aquariums



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1. Introduction

1.1. A Collaborative Approach to Conservation

The practice of conserving wildlife and their habitats is complex and multi-faceted. There are many ways to analyze and categorize the diverse approaches to wildlife conservation [1], but broadly, wildlife conservation practices may be separated into two categories—ex situ and in situ conservation [2]. Traditionally, wildlife biologists, researchers, land managers, and conservationists work together to develop and implement conservation practices for wildlife and their habitats in the field (i.e., in situ). Meanwhile, ex situ efforts focus on the conservation and maintenance of animal populations outside their natural habitats, often through breeding and rearing programs. In recent years, however, there has been increased recognition of the value of a more integrated approach to wildlife conservation wherein these two tracks function together [3]. The Conservation Planning

Specialist Group's (CPSG) One Plan approach embodies this integrated process and is modeled on "the development of management strategies and conservation actions by all responsible parties for all populations of a species, whether inside or outside their natural range" [4]. This requires that conservation planning for a species simultaneously considers the management of both captive and wild populations.

1.2. Role for Zoos and Aquariums

The science and practice of wildlife conservation have been orchestrated by a variety of organizations for as long as the field has formally existed. Non-profit organizations, government agencies from the federal level to local community-based organizations, and educational institutions such as universities are all actively involved in conservation efforts today, each filling its own niche within the broader conservation landscape. Zoos and aquariums, often operating as not-for-profit and public organizations [5], primarily have focused on ex situ conservation but have supported in situ initiatives as well. These ex situ efforts have influenced the field through coordinated breeding programs that can create "insurance" populations for at-risk animals and may serve to augment wild populations. While captive breeding programs are coordinated almost entirely outside of a species' natural range, these managed populations may provide a source for population augmentation, such as reintroducing species to their wild habitats. A well-known example is the Asian wild horse (Przewalski's horse; *Equus ferus przewalskii*). Once found throughout the grassland steppes of Europe and Asia, the Asian wild horse was officially declared extinct in the wild in the 1960s [6]. After years of ex situ breeding efforts coordinated largely by zoos, these animals were reintroduced in the wild in partnership with local organizations, leading to the successful establishment of in situ populations in areas of Europe and Asia [7].

Zoos and aquariums are uniquely positioned to support a collaborative One Plan approach to wildlife conservation. Institutions typically maintain large and diverse collections of animals that may be managed to meet ex situ conservation objectives (e.g., as a source for conservation translocations) and have the ability to reach large audiences with conservation messaging and encourage public action. They often participate in captive breeding programs and thus maintain staff and institutional expertise in reproductive biology and small population management. Zoos and aquariums can conduct important trial research to help create and inform conservation protocols when pre-existing knowledge is lacking, such as the development of breeding and rearing techniques for species that have not been managed in a captive setting previously. In addition, zoos and aquariums are very specialized facilities with spaces and equipment designed specifically for the rearing and caring of animals. Staff are highly experienced in animal husbandry which can be a significant asset for head-starting and reintroduction programs. Zoo veterinary expertise also helps manage health-related concerns of head-starting and insurance populations and ensures that animals designated for translocations are in adequate physical condition.

The Association of Zoos and Aquariums (AZA) is a non-profit organization "dedicated to the advancement of zoos and aquariums in the areas of conservation, education, science, and recreation" [8]. There are currently 238 institutions across 13 countries that are accredited by AZA, collectively drawing more than 200 million visitors annually [9]. About 900 species housed at AZA facilities are classified by the International Union for Conservation of Nature (IUCN) as Vulnerable, Endangered, Critically Endangered, or Extinct in the wild [5]. AZA institutions don't just house animals from across the globe, however. AZA institutions are also actively and increasingly involved in field conservation efforts, with 117 recognized reintroduction programs coordinated by AZA members [5]. In 2020, AZA institutions collectively spent >\$208 million on field conservation [9].

1.3. Minnesota Zoo

The Minnesota Zoological Garden (MN Zoo) is an AZA-accredited institution located in Apple Valley, Minnesota, USA. Situated on nearly 500 acres, the MN Zoo houses close to

5000 animals and over 490 species, approximately 15% of which are listed as imperiled at international, federal, or state levels. As the largest environmental education institution in the state, we welcome over 1.3 million guests through our doors in a typical year (before the COVID-19 global pandemic). We are one of only two zoos in the United States that operates as a state agency (the North Carolina Zoo is an agency of the North Carolina Department of Natural and Cultural Resources), which makes our institution relatively unique and impacts our conservation approach in a variety of ways.

Our current conservation portfolio includes both local and global species. Most of our work, however, takes place in Minnesota with efforts focusing on the conservation of pollinators, freshwater turtles, native freshwater mussels, and North American plains bison (*Bison bison*). The origin of these programs was significantly shaped by our unique circumstances as both an AZA-accredited zoo and aquarium and a state agency, and this impact continues today. Here, we review our portfolio of local conservation projects and identify common threads among those programs that allow us to understand how we, as a zoo and an agency of the state of Minnesota, are uniquely positioned to contribute to wildlife conservation in the Upper Midwest USA.

2. Case Studies

The MN Zoo's active local projects address the conservation of pollinators, freshwater turtles, native mussels, and North American plains bison. We evaluate each program using four guiding parameters to lend structure to the review and maintain consistency. We begin by providing the reader with programmatic context, including the target species, threats, local conservation status, and initial programmatic objectives and activities. Next, we consider primary partnerships that have influenced the program, including historical, current, and developing collaborations. The overall growth of each initiative throughout the years is examined, followed by the main source(s) of funding.

After reviewing each of our Minnesota-based conservation initiatives using these parameters, we identify common themes and detail lessons learned throughout the remainder of the paper.

2.1. Pollinator Conservation Initiative

2.1.1. Context

The MN Zoo's Pollinator Conservation Initiative (PCI) began in 2012 with the intent to focus on field surveys and research, and the possible eventual reintroduction of two of the state's vanishing butterfly species. Minnesota once boasted about 18 million acres of rolling tallgrass prairie [10] which supported a diverse array of wildlife. Over the last century, the vast majority of that landscape was converted to agriculture and development [11] and many of the species that relied on the prairie were lost with it [12–14]. The Dakota skipper (*Hesperia dacotae*) and Poweshiek skipperling (*Oarisma poweshiek*) were both commonly found throughout Minnesota's prairies [15,16] but have experienced dramatic population declines range-wide in recent decades [17,18]. Both species are now listed under the U.S. Endangered Species Act [19]; the Dakota skipper is categorized as Endangered [20] and the Poweshiek skipperling as Critically Endangered [21] by the IUCN. They are among a handful of butterflies listed at the State level by the Minnesota Department of Natural Resources (DNR).

2.1.2. Partnerships

When the PCI first started, little was known about the state of wild populations of Dakota skipper and Poweshiek skipperling. The MN Zoo's Conservation staff were in close and regular contact with other government agencies including the DNR and the United States Fish and Wildlife Service (USFWS). Biologists within these agencies expressed concern that these species were declining as reported sightings became less frequent and both were undergoing listing assessments by USFWS. Our initial role was to survey sites where the species were known to historically occur in the hopes of gaining

a better understanding of their population status. As surveys continued over the first few years, it became clear that Dakota skipper populations had declined rapidly and that the Poweshiek skipperling was on the verge of extirpation in—if not already extirpated from—Minnesota [19].

Through a series of subsequent workshops (including a variety of partners) following ex situ planning guidelines established by the IUCN [22], potential roles for ex situ conservation programs were identified to support the recovery of both butterfly species in North America [23]. The MN Zoo was uniquely positioned to aid in these specific efforts. As an institution with nearly 40 years of experience rearing and breeding animals for conservation initiatives, we were able to lend our expertise and build the ex situ aspect of the butterfly program. Although ex situ breeding and reintroduction programs have been an increasingly implemented conservation tool [24,25], initially no protocols existed for rearing and breeding these species or any grass skipper (sub-family Hesperinae). The MN Zoo's biologists worked closely with other MN Zoo staff to design appropriate facilities (Figure 1) and began to build the protocols necessary for the rearing and managed breeding of Dakota skipper and Poweshiek skipperling.



Figure 1. Imperiled Dakota skipper larvae are reared on host plants inside butterfly hoop houses at the Minnesota Zoo. Poweshiek skipperling are reared in similar facilities on campus.

2.1.3. Growth

Once husbandry protocols were successfully developed, the PCI expanded quickly. Adhering to the IUCN's Translocation guidelines [26], we have partnered closely with The Nature Conservancy and DNR on Dakota skipper conservation, as well as with collaborators in Michigan, where the last remaining wild populations of Poweshiek skipperling in the USA are now found, to coordinate the site surveys and determine the scope and form of releases of zoo-bred butterflies. Both Dakota skipper and Poweshiek skipperling are prairie obligate species, and candidate sites for reintroduction and augmentation are located hundreds of miles from the MN Zoo campus. As a zoo, the management of natural areas and sites lies outside our purview. Thus, partnerships have been critical to the implementation of in situ conservation work as well as the overall growth and success of this program. The PCI began with efforts focused on head-starting to help augment wild



Figure 2. A reintroduced male Dakota skipper reared at the Minnesota Zoo perches atop a purple coneflower at a reintroduction site in southwestern Minnesota.

populations and has since shifted to managing captive breeding populations which serve as a source for translocations (Figure 2). We are now able to rear about 3000 Dakota skipper and approximately 400 Poweshiek skipperling per year for breeding and release efforts. The list of collaborators is also expanding. We are currently working with biologists at John Ball Zoo and Assiniboine Park Zoo which has doubled the capacity to rear and translocate Poweshiek skipperling. Additional accredited zoos may be joining Dakota skipper ex situ efforts in the near future.

The PCI has continued to shift and grow over the last decade as needs have been identified and research has developed. Closer to home, the PCI has recently expanded into research and outreach for other pollinators, particularly the U.S. Endangered rusty patched bumble bee (*Bombus affinis*) which exists wild on the MN Zoo campus. MN Zoo biologists are involved in federal recovery planning efforts for all these species, utilizing quantitative decision tools and facilitating large partnerships. Additional research conducted by MN Zoo biologists has included studies on some of the probable stressors on globally endangered Poweshiek skipperling and Dakota skipper. For example, we have documented the near-universal presence over many years of multiple agricultural pesticides, particularly broad-spectrum insecticides targeting the economically damaging soybean aphid, within federally designated Critical Habitat for these protected butterflies in the Upper Midwest. We have also shown experimentally that some invasive grass species in these same prairies are likely presenting ecological sinks to Dakota skippers by decreasing survivorship and delaying the development of their larvae that may feed on these less suitable hosts [27].

All our field conservation programs have sets of long-term goals, objectives, and associated actions to structure our work. Objectives and activities are established in coordination with our partners and, where possible, guided by formal recovery plans, such as with Poweshiek skipperling work. Our progress toward meeting objectives is revisited regularly and we adapt our work as necessary to address emergent needs and unforeseen issues. Success is evaluated based on a variety of metrics that are specific to each program.

For PCI work, metrics include survival at key life history stages, breeding rates of captive-reared animals, total numbers of individuals released via population augmentation efforts, and hatching rates of wild-collected eggs. We also evaluate success based on our ability to disseminate key findings and activities to the scientific community via publications in the peer-reviewed literature, presentations at professional conferences and meetings, and technical reports.

2.1.4. Funding

As is the case with much conservation work, external funding has played a significant role in shaping this initiative. Minnesota's Environment and Natural Resources Trust Fund (ENRTF) is awarded annually to a variety of grantees "for the public purpose of protection, conservation, preservation, and enhancement of the state's air, water, land, fish, wildlife, and other natural resources" [28]. The MN Zoo's Dakota skipper operations have been funded in large part by the ENRTF over the last decade which mandates that appropriations be awarded to projects operating within the state. Thus, the reintroductions of Dakota skipper to date have necessarily been constrained to Minnesota. As the remaining known sites for Poweshiek skipperling are outside Minnesota we cannot use State funds for this project. The PCI has largely depended on federal funding, via grants such as the Great Lakes Restoration Initiative (GLRI), to execute Poweshiek skipperling work. Additional programmatic support is provided by the MN Zoo, Minnesota Zoo Foundation, and other organizations. The ENRTF and GLRI funds have provided primary support for two dedicated full-time entomologists who focus exclusively on these programs, as well as a few seasonal staff during peak husbandry and field season.

2.2. Freshwater Turtles

2.2.1. Context

Minnesota, also known as the 'Land of 10,000 Lakes', is home to an abundance of freshwater resources. Nine species of turtles are native to the state including the wood turtle (*Glyptemys insculpta*), Minnesota's most terrestrial turtle species [29]. Habitat degradation and destruction, collection for the pet trade, and increased road mortality and predation [30], compounded by the species' low reproductive potential, have impacted the population throughout its range in North America [31,32]. In 1984, the wood turtle was listed as threatened by the DNR and is now only found at a few sites within the state [33]. The USFWS is completing a status assessment for potential listing under the Endangered Species Act on both the wood turtle and Blanding's turtle (*Emydoidea blandingii*), another species native to Minnesota [34,35].

2.2.2. Partnerships

Similar to the Pollinator Conservation Initiative, the MN Zoo's freshwater turtle conservation program began in partnership with other government agencies, including the DNR and the Minnesota Department of Transportation (MnDOT). Because both wood and Blanding's turtles are protected in Minnesota, the DNR has been conducting research and implementing conservation activities for years [29,36] and our objective was to support their ongoing research and conservation efforts. Specifically, in 2017, we began partnering with the DNR to use GPS telemetry to document the movements and habitat use of wood turtles and to identify and protect key nesting sites, and with MnDOT to mitigate road mortality.

2.2.3. Growth

Over the first few seasons, we collected valuable information on the spatial ecology of wood turtles including range size, habitat use, and the distribution of nesting sites. However, it also became evident that wood turtles were suffering from poor recruitment due to factors including high rates of nest predation such that additional measures would be needed to maintain local populations while threats could be addressed. As such, with the support of the DNR we initiated a formal head-starting program whereby eggs

would be collected from the wild and hatchlings reared through their first year of life before being released to natal sites to help bolster wild populations. The head-starting program has grown considerably over the years and program staff at the MN Zoo now rear approximately 30 turtles from hatching through their first year (Figure 3). Before release back into their natural habitats, a sample of the yearling wood turtles is outfitted with VHF transmitters so they can be routinely tracked by biologists. Little is currently known about the habitat use and survivorship of yearling wood turtles [29], and these data will inform the conservation of the species and help to evaluate the success of the head-starting program.



Figure 3. Wood turtle hatchlings are reared at the Minnesota Zoo for their first year of life as part of the head-starting program.

In addition, MN Zoo biologists partnered with MnDOT to study road mortality and mitigation strategies via a Before-After Control-Impact study design [37]. This research suggested that standard chain link fences outfitted with j-hook wrap-around end treatments can be an effective means to mitigate the mortality of turtles on Minnesota's roadways (Figure 4). At some sites, turtle mortality was reduced by 90% with the installation of fencing [37]. While the initial research project concluded in 2022, MN Zoo biologists continue to work with staff and researchers at MnDOT and other local road authorities to implement and improve roadside fencing in order to reduce mortality and ensure turtles and other wildlife have safe passageways.

Lastly, we are expanding our partnership with the DNR and delving into a new initiative within the freshwater turtle program. While widespread across the state, Blanding's turtles have experienced range-wide population declines over the last decades [38]. The southeastern corner of Minnesota hosts one of the largest historical populations of Blanding's turtles in North America [39], but little is known about the current status of this population. MN Zoo and DNR biologists are conducting pilot work to inform a larger-scale study that will estimate demographic metrics, assess the status and evaluate the resiliency of this important population in Minnesota.

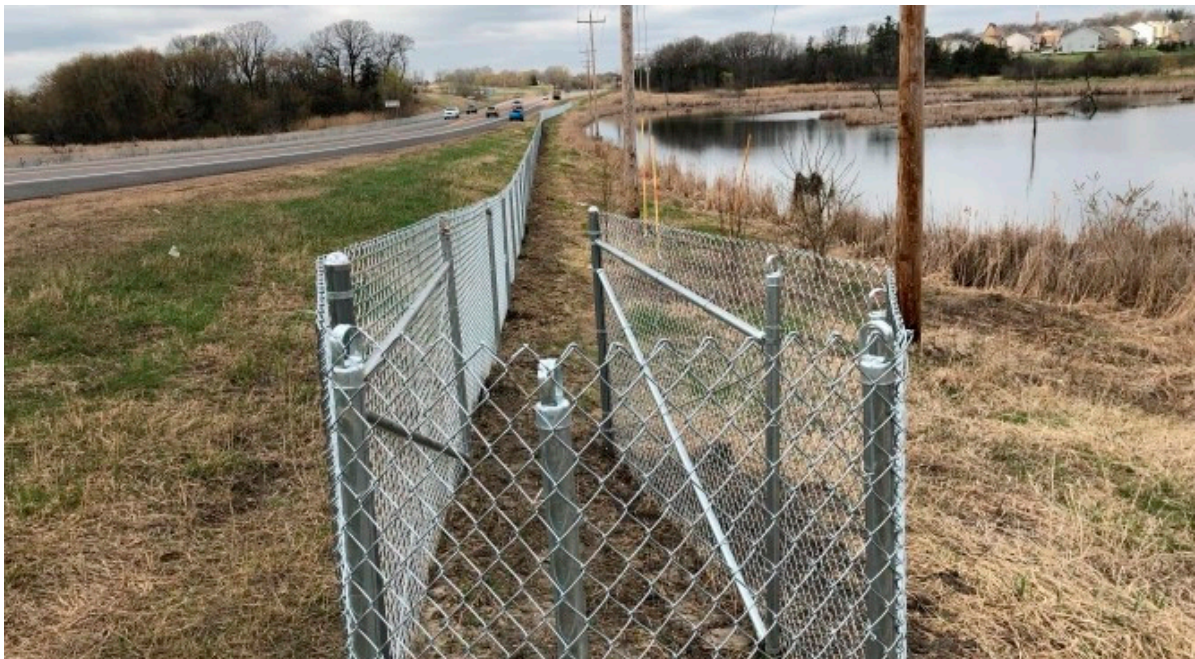


Figure 4. Chain-linked fences with wrap-around end treatments and retrofitted with fine mesh hardware cloth at the base effectively reduce the mortality of turtles on Minnesota's roads.

Key performance indicators for our turtle conservation program have varied by initiative (i.e., head-starting and documenting spatial ecology of wood turtles, mitigating road mortality, and updating the demographic status of Blanding's turtles). Specific metrics have included the number of transmitters deployed on wood turtles, number of eggs collected from the wild, hatching rates of wild-collected eggs, growth rates of animals in our care, number of individuals released via head-starting efforts, post-release survival of head-started wood turtles, percent reductions in mortality after implementation of mitigation measures, and trap nights and capture rates of Blanding's turtles (which will provide the foundation for our demographic assessments).

2.2.4. Funding

Primary financial support for our freshwater turtle program is provided by Minnesota's ENRTF, which has awarded grants to the MN Zoo for these efforts since 2018, and a contract with MnDOT which supported our research on the efficacy of small animal exclusion fencing in reducing the mortality of turtles and other wildlife. In addition, we receive supplemental funding from the MN Zoo's state appropriation and the Minnesota Zoo Foundation. Staffing currently includes one full-time biologist who exclusively implements turtle research and conservation activities and a seasonal internship that is shared with the freshwater mussel program.

2.3. Native Freshwater Mussels

2.3.1. Context

Freshwater mussels are found throughout much of the world, but North America is a biodiversity hotspot, boasting nearly 300 species of native mussels [40]. Unfortunately, native mussel populations in the United States have experienced steep declines since the late 1800s [41]. Historic overharvesting of mussels for the pearl button industry, the construction of dams, pollution, and aquatic invasive species are among the factors that have led to the categorization of freshwater mussels as the most at-risk group of animals in North America today [42].

Much of Minnesota is dotted with freshwater lakes and wetlands, with miles of winding river carving through the landscape, providing plentiful potential habitat for

mussels. The state is home to dozens of species of native freshwater mussels, which play a crucial role in the health and vitality of Minnesota's aquatic resources [43]. The DNR has studied and surveyed native mussels since the late 1990s and propagates and conducts reintroductions for some of the 28 species of conservation concern at the State and federal levels [44].

2.3.2. Partnerships

The MN Zoo began its involvement in mussel conservation in 2015 by partnering with and supporting the efforts of the DNR. Following consultation with the DNR, we concluded that we could best contribute via head-starting juvenile stock provided by partner organizations. With years of experience rearing species with similar life histories and requirements as mussels, we were well-positioned as a partner for ex situ conservation work. MN Zoo staff expertise with coral propagation and the maintenance of aquatic systems has been an asset to building the infrastructure for the freshwater mussel program. The MN Zoo is also located on hundreds of acres of land, much of it undeveloped, with access to several small lakes and wetlands that have been critical to the expansion of the ex situ efforts.

2.3.3. Growth

The mussel program began at the MN Zoo by rearing a few hundred juvenile mussels in five-gallon buckets in one of the small lakes on our grounds (Figure 5). Our work and capacity to rear mussels have expanded significantly since the program's inception in 2015. We constructed docks at an alternative lake with high-quality water and installed new baskets for rearing. In collaboration with staff from the Aquariums and Life Support departments, we designed and constructed a new rearing and research facility that further expanded our physical capacity (Figure 6). The addition of the rearing facilities also allowed us to construct specialized systems for newly transformed mussels, which are nearly microscopic in size and notoriously difficult to rear. Today, the MN Zoo's mussel-rearing facilities collectively have the capacity to house >100,000 individuals.



Figure 5. The Minnesota Zoo head-starts native mussels to support recovery efforts led by the Minnesota Department of Natural Resources. Mussel growth is demonstrated by comparing individuals at one year of age (**left**) and after one year of head-starting at the MN Zoo (**right**).



Figure 6. The Minnesota Zoo's native mussel facility includes individual rearing pans which allow for manipulation of metrics such as substrate, flow rate, and mussel density to facilitate experimentation. Water is circulated from a nearby lake.

The propagation of mussels has been studied for years, but much remains unknown about the natural history of native mussels and how best to rear many species [45]. As such, in addition to helping expand the rearing capacity of our partners, we have conducted research to inform these husbandry protocols and systems. Current studies include how the presence of larger size classes and different substrates impact the growth and survival of individuals.

We are now supporting the conservation of native mussels in other new ways. Freshwater mussels require a fish host to complete their development, and DNR researchers rear host fish as part of their propagation programs. Establishing and maintaining the appropriate facilities for the husbandry of both freshwater mussels and their fish host species requires significant space, time, and experience. The MN Zoo recently began rearing young walleye (*Sander vitreus*), a common mussel host fish, provided as fingerlings from local hatcheries to aid in the successful propagation of mussel species. The pilot year was successful with high survival, and we subsequently built permanent structures so that we can continue rearing ~200 walleye a year to support mussel conservation efforts. Measures of success for our mussel program include survivorship and growth of animals in our care and numbers of animals returned to the DNR for eventual release into the wild (or with fish hosts, for inoculation with mussel larvae) as a result of our head-starting programs.

We are also currently conducting research in collaboration with the University of Minnesota's Aquatic Invasive Species Research Center (MAISRC) on the invasive zebra mussel (*Dreissena polymorpha*). Originally native to freshwater in Eurasia, zebra mussels likely arrived in the U.S. in the 1980s and have negatively impacted our lakes and rivers and native mussel populations dramatically [46]. In 2020, MN Zoo biologists began conducting research with scientists at MAISRC on how to rear zebra mussels in a controlled setting. The goal is to establish rearing protocols and to provide zebra mussels at all life stages for researchers working on eradication and control methods.

2.3.4. Funding

As with our other programs, Minnesota's ENRTF has played a critical role in the establishment and growth of the mussel conservation program. Initial funding from the ENRTF provided primary support for staff time and the construction of our mussel research and rearing facility. A subsequent award from ENRTF has supported the maintenance and further expansion of our work; supplemental funding is provided by the MN Zoo state appropriation and the Minnesota Zoo Foundation. The MN Zoo's mussel conservation program is staffed by one full-time biologist and a seasonal internship shared with the turtle program, with additional support provided by the Life Support and Aquariums departments. The zebra mussel research is currently funded by the University of Minnesota via the Minnesota Aquatic Invasive Species Research Center.

2.4. North American Plains Bison

2.4.1. Context

North American bison once numbered in the tens of millions and inhabited great expanses of the continent [47]. Throughout the 19th century, bison were hunted to near extinction by European settlers until fewer than 1000 individuals remained [48]. Coordinated conservation efforts helped save the species from extinction and resulted in successful reintroductions at sites across North America [49]. During the recovery period, however, domestic cattle (*Bos taurus*) were allowed to breed with many of the few remaining bison populations, altering their genomic makeup [48]. Previous studies have estimated that approximately one percent of today's North American bison are free of cattle genes [48], although more recent evidence suggests that all bison today have some degree of cattle genomic introgression [50]. The overall resulting effects of cattle genes within bison populations, an animal that has existed in North America for thousands of years, are largely unknown [51].

For the long-term conservation of the species, it is critical that bison genetics are managed through healthy herds across their historical range. Many of the original populations reintroduced on public lands over the last few decades, such as at Yellowstone National Park, have reached carrying capacity. The National Park Service recommended that smaller satellite herds, such as those at state parks, be established and managed to ensure the future health and conservation of bison in North America [52].

2.4.2. Partnerships

In 2012, the Parks & Trails Division of the DNR and the MN Zoo joined together to form the Minnesota Bison Conservation Herd (MBCH). The partnership was established with two primary goals: to reestablish a Minnesota bison population of sufficient size to sustain genetic diversity and contribute to bison conservation in North America, and to provide increased opportunities for visitors to connect with the species. The targeted population of the MBCH is set at 500 individuals, made up of several smaller satellite populations but managed collectively [52]. The well-established collaborative relationship between the MN Zoo and the DNR has aided the conservation efforts substantially. The DNR has jurisdiction over many acres of land that could provide potential bison habitat. Because of the unique history of bison in North America and their breeding with cattle, it is important to understand and actively manage the genetic makeup of the overall herd. MN Zoo staff have extensive experience in cooperative breeding and studbook management and have been able to leverage this expertise in support of the bison program. In order to reach the targeted goal of 500 individuals and to ensure the future success of the species, partnerships have been and will continue to be essential.

2.4.3. Growth

The Parks & Trails Division of the DNR has been managing bison in the state since three animals were reintroduced to Blue Mounds State Park in 1961. Since then, the herd at Blue Mounds State Park has grown substantially (Figure 7), and a new herd was

reintroduced at Minneopa State Park in 2015. Expansion of the MBCH has continued with the addition of new partners and the creation of more satellite herds. Today, the MBCH is comprised of approximately 130 animals at five sites across the state: two state parks, two zoos (including the MN Zoo), and a county park. There remains considerable opportunity for growth as additional organizations have recently expressed interest in establishing or expanding bison herds as a part of the MBCH.



Figure 7. Bison at Blue Mounds State Park, part of the Minnesota Bison Conservation Herd, are monitored and provided health checks during the annual management event in October 2022.

We measure the success of this program via metrics such as the overall genetic diversity of the MBCH, minimization of cattle genomic introgression, the size of the MBCH herd (relative to carrying capacities of individual sites and our stated target of 500 individuals), and the expansion of the MBCH to incorporate new partner organizations from across the State.

2.4.4. Funding

Funding and support for the bison conservation work come from a variety of sources. The MN Zoo's Animal Care staff, who care for the MN Zoo's bison herd and support the annual management event, and the Animal Health staff, who provide healthcare to our bison and some MBCH satellite herds, are primarily supported through our general operating budget. Individual and institutional contributions made to the Minnesota Zoo Foundation help fund the genetic analysis, conducted by the DNA Technologies Core Laboratory at Texas A&M University, as well as equipment and supplies needed for the program. The MN Zoo's bison conservation program is coordinated by a dedicated biologist with additional support provided by other members of the Conservation team as well as the Animal Health and Animal Care staff.

3. Lessons Learned

Wildlife conservation can be accomplished through many tactics, including both in situ and ex situ programs. Different institutions are best positioned to contribute to

conservation in specific ways depending on their expertise and available resources. Zoos and aquariums are unique players in the conservation field today, due in part to their specialized facilities, staff expertise in ex situ conservation programs and animal care and health, access to large audiences, and diverse animal collections. As zoos and aquariums continue moving towards conservation-minded missions and initiatives that leverage their expertise and partnerships, there may be increased opportunities to contribute directly to local wildlife conservation [53]. By examining the history and current status of the MN Zoo's four main local conservation programs, and considering our unique status as a state agency, we summarize a few key lessons learned from our own experiences.

Our status as a state agency necessitates our focus on local wildlife.

As a state agency, the MN Zoo is committed to serving Minnesotans by bringing our mission to life through the conservation of wildlife within the state and by connecting people to nature. Much of our field conservation work is directly supported by state funds, and our current portfolio of projects remains largely focused within Minnesota. We are orchestrating five significant field conservation projects and four of these (pollinators, turtles, freshwater mussels, and bison) are almost entirely located in Minnesota; three of these programs are funded in large part by the state's ENRTF. We also currently coordinate a black rhino conservation program in Namibia, but this initiative is funded exclusively by the Minnesota Zoo Foundation, the affiliated 501c3 that helps provide support to the MN Zoo, since state funds cannot be used to support an international project.

Additionally, as a government agency, we receive a bi-annual appropriation from the state that helps support our programs. Of course, species-focused conservation work often entails needing to work across states and even countries, which has compelled us to look for additional financial support. Soon after the Poweshiek skipperling work at the MN Zoo began, the remaining populations within the state disappeared. We thus have secured funding from organizations outside the state to continue working with the remaining population in Michigan.

Partnerships are essential for fledgling, zoo-based conservation initiatives and necessary to advance institutional field conservation objectives.

One of the most influential factors for the MN Zoo's conservation work has been our standing and newly formed partnerships. Not only have our partnerships been hugely influential as our conservation programs have grown, but many of our current projects likely would not have started without them. The MN Zoo's pollinator, turtle, native mussel, and bison initiatives all came to fruition or were shaped dramatically by standing relationships, most notably with the DNR. The identified conservation needs and how best we could leverage our assets as a zoo-based conservation organization informed our initial roles. When initially structuring our conservation programs, we found it most logical and productive to support existing programs through our partnerships rather than create new programs entirely with our own resources. Perhaps surprisingly, the standing collection of animals at the MN Zoo at the time these programs were created had little to no bearing on how these conservation initiatives took form.

Today, our Minnesota-based conservation programs continue to benefit greatly from a robust portfolio of partnering institutions. While we are fortunate to have access to the natural landscapes of the MN Zoo, our jurisdiction ends there. In order to conduct off-site surveys and species reintroductions, we need to collaborate with a variety of institutions. This is evident in all our field projects. The reintroductions and surveys for wood turtles, prairie butterflies, freshwater mussels, and bison all rely on the cooperation of other organizations and individuals. To structure and conduct effective conservation programs, both in situ and ex situ efforts should be considered, and for our programs, this has only been made possible through a collaborative approach.

As an agency of the State of Minnesota, we are well-positioned to partner with other government agencies to benefit conservation.

Many of our partners also operate under the state's jurisdiction. The Minnesota Department of Natural Resources, another state agency, is a key partner across all our field initiatives. We also maintain close relationships with the Departments of Transportation and Corrections, as well as with the University of Minnesota, which is the largest public university system in the state. In several ways, our status as a state agency has facilitated and simplified our ability to work with other large state institutions. As we operate under many of the same guidelines and procedures, formalizing partnerships and agreements is often simpler and faster than if we were entering into similar partnerships with an organization outside the state system. It has also promoted our ability to work with other government entities including the U.S. Fish and Wildlife Service and county governments. State agency status has even created mandates for conservation partnerships with other agencies. For instance, the MN Zoo has been directed under Minnesota Governor's Executive Orders 16-07 [54] and 19-28 [55] to be a member of the Interagency Pollinator Protection Team, a group of ten state agencies convened to advance pollinator conservation and engagement in Minnesota. This membership has necessitated staff time but also has fostered relationships and decreased silos with other agencies.

Programmatic flexibility and opportunism have been key in maximizing growth potential.

In examining our portfolio of current projects, it is evident how significantly our work has grown and pivoted at times throughout the past decade. The Pollinator Conservation Initiative was created to help assess the current status of two potentially declining butterfly species, and we now have pioneered and implemented a robust rearing and breeding program for both the Dakota skipper and Poweshiek skipperling, working with partners across the continent to save them from extinction. Our freshwater turtle conservation work continues to grow as we now have a well-established head-starting program for wood turtles and are expanding efforts to encompass the threatened Blanding's turtle as well. The native mussel program is rearing more individuals and new species, including walleye, in facilities at the MN Zoo and in partnership with the DNR, and now has a new focus on the invasive zebra mussel. Lastly, the Minnesota Bison Conservation Herd continues to seek out and create new partnerships as it works to meet its goal of a statewide collective herd of 500 animals.

Over the years, we have found it necessary to consistently reevaluate the conservation landscape, maintain communication with our partners, and reassess how the MN Zoo can best support those efforts. Shifting conservation priorities and the changing capacities of our partners have frequently warranted a directional change within our own programs. The growth and expansion of these programs is exciting, and the ability to shift focus as the ever-changing needs develop is imperative to their success.

The Minnesota Zoo's ability to procure external grants to support its conservation initiatives has resulted in programmatic siloing.

As is the case with many other conservation programs, the various funding streams that we have received over the years have significantly impacted our conservation efforts. Currently, much of our work is supported through Minnesota's Environment and Natural Resources Trust Fund (ENRTF). The money in this fund is generated by the State Lottery and administered each year by the Legislative-Citizen Commission on Minnesota's Resources. Since 1991, the ENRTF has funded approximately \$700 million to thousands of projects across the state [28].

We have found that having projects sustained by external grants can create a silo effect. Since staff time is largely supported by grants to work on specific projects and must be reported on periodically, there is typically little flexibility for departmental staff to work and help with other field projects which would be especially desirable during the busy field season. It is also challenging to build institutional knowledge and ensure programmatic continuity when staff are mostly confined to working within their programs. The specifics of the grant and the awarding institution can additionally influence how a conservation project functions. A change in funding may result in a necessary pivot in one way or

another. As our conservation programs continue to grow, maintaining programmatic flexibility will be essential to their success. Transitioning toward a model that is less reliant on external grant funding will improve efficiency and programmatic sustainability and effectiveness. Specifically, we hope to support the salaries of full-time Conservation staff via the MN Zoo's general operating budget and use external grants to fund project-specific costs, such as equipment and supplies, travel, and temporary staff that may be necessary for implementation.

However, grant funding can buffer against the impacts of economic uncertainty and severe downturns.

Relying on grants as a main source of financial support typically lends some instability from year to year as exact future funds are unknown. During the initial phase of the COVID-19 pandemic, however, our reliance on grant funding offered our department rare and unexpected stability. As with many institutions across the globe, the MN Zoo was forced to close its doors for months in response to the pandemic which necessitated lay-offs for a significant portion of the workforce and dramatic spending cuts. Because our funding came from external sources outside of the MN Zoo's general operating budget, our local conservation programs were spared from staff layoffs and many other budgetary cuts.

4. Conclusions

By reviewing and analyzing the history and current status of our conservation initiatives, we can piece together how the MN Zoo has leveraged its unique strengths and assets to impact local wildlife conservation. Similar to other zoos, the MN Zoo remains well-positioned to aid in ex situ efforts, especially in the formation and execution of head-starting and similar programs, largely due to our facilities and staff expertise across the organization.

In addition, our designation as a state agency, rare among zoos and aquariums, has shifted our focus towards local efforts as a result of the financial support received from State of Minnesota sources and our ability to partner with other government agencies. This local focus is not necessarily typical for AZA institutions. Whereas about 90% of AZA member institutions are located in the US [9], only 45% of field conservation projects took place within the country in 2021 [56]. By contrast, 80% of the MN Zoo's major field research projects take place entirely within the US (and primarily within Minnesota). As our focus has localized and changed over the years, we have learned that maintaining a degree of programmatic flexibility is key to the successful growth and impact of our conservation initiatives.

We suggest that other institutions consider focusing a larger portion of their conservation portfolios on local initiatives; local wildlife also may require conservation attention and may represent a more efficient investment of limited resources. Moreover, our experiences suggest that local conservation impact can resonate with zoo visitorship, even if the target species are not considered charismatic megafauna (in our case, butterflies, mussels, and turtles). Although our role as a state agency has helped facilitate the partnerships necessary to engage in local conservation, zoos and aquariums without that standing can familiarize themselves and engage with their unique local conservation partners to ensure an impactful and collaborative approach.

Constructing and understanding our own narrative is valuable in considering what the MN Zoo's initiatives may look like in the future so that we can build our efforts to have a significant and lasting conservation impact. As we have learned through the development and growth of our own local conservation programs, zoos and aquariums can play a critical role in wildlife conservation. Every institution, however, has its own unique background, and individual strengths and narratives are likely to vary considerably among organizations based on that context. We encourage other zoos and aquariums to undertake a similar analysis of their own programs when setting future conservation goals and priorities.

The role of zoos and aquariums has changed significantly over time, from entertainment centers focused on providing the public with a view of often rare and exotic animals to collaborative institutions with a mission to save wildlife and champion animal welfare [57]. In the fight to save wildlife, the global community must utilize every tool at its disposal, leveraging the distinct assets that each organization brings to the table, including zoos and aquariums.

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