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The contribution of zoos and aquaria to Aichi Biodiversity Target 12: A case study of Canadian zoos

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ABSTRACT

The purpose of Aichi Biodiversity Target 12 is to prevent extinction of known threaten species, and improve the decline of the world's most imperiled species. Governments and NGOs around the world are actively working toward this goal. This article examines the role of zoos and aquaria in the conservation of species at risk through an in-depth examination of four accredited Canadian zoos and aquaria. Through site visits, interviews with staff, and research into the programs at each institution, this paper demonstrates that captive breeding, reintroductions, and headstarting projects are each a large component of conservation efforts. Interviews with zoo staff reveal strong consensus that zoo offer two critical components for species at risk conservation: space and expertise. Overall, this article calls for greater attention to the types of conservation actives occurring and the ways in which zoos are working together to protect and recover global biodiversity.

1. Introduction

Human activities have catastrophic ramifications for the world's biodiversity, with habitat loss, overhunting, pollution, climate change, and other factors leading to the current imperilment of over 23,250 species around the world (IUCN, 2015). To mitigate this global crisis it is necessary that species be protected from further harm. Governments have recognized this need and signatories to the United Nations Convention on Biological Diversity have committed to a Strategic Plan for Biodiversity 2011–2020. There are 5 broad strategic goals and 20 targets, which are known as the Aichi Biodiversity Targets (https://www.cbd.int/sp/targets). Numerous countries have species at risk legislation, and 183 countries now endorse the global Convention on the International Trade in Endangered Species of Wild Fauna and Flora. However, government action alone will not be enough. There is a need for civil society and non-governmental organizations to actively assist with preservation of species at risk.

This paper turns attention to the role that zoos and aquaria (hereafter "zoos") play in the conservation of species at risk. Moss et al., (2015) argue that zoos contribute to Aichi Target 1 through enhancing awareness of biodiversity (see also Conde et al., 2015; Gusset et al., 2014). Here it is argued that zoos also have a significant role to play in other Aichi Biodiversity Targets, specifically Target 12, which states, "by 2020, the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained" (https://www.cbd.int/sp/targets). Research conducted inside four Canadian zoos suggests potential for zoos to engage not only in the prevention of extinction, but also in the protection and recovery of imperiled species.

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2. Literature review

Human beings have kept animals in captivity for thousands of years, with the earliest known zoo being a menagerie from 3500 BC in the ancient city of Hierakonpolis, Egypt (Rose, 2010; Patrick and Tunnicliffe, 2013). Captive animals during this time were seen as evidence of an individual's wealth and power. The first "modern zoo" open to the public was the Schönbrunn Zoo in Vienna, Austria, which was originally established as a private park by the Holy Roman Emperor Maximillian in 1569. Emperor Joseph II decided to make the zoo available to the public in 1765, beginning a chain of events that saw many formerly private zoos turn public, and new public zoological institutions come into being (Patrick and Tunnicliffe, 2013). Entertainment was the highest priority of these new public facilities.

Throughout the 20th century, many zoos began another evolution, shifting from an entertainment focus to one of scientific research and conservation (Hallman and Benbow, 2006; Patrick and Tunnicliffe, 2013; Rees, 2011). This shift was exemplified by the International Union of Directors of Zoological Gardens (IUDZG) 1993 World Zoo Conservation Strategy, which set out goals for zoos around the world, and asked that these institutions dedicate their efforts toward conserving nature (IUDZG/CBSG, 1993).

Today, it is widely known that zoos keep animals in captivity and that some zoos breed animals. In fact, this is often a source of public scrutiny and criticism, and, ironically, it can also be the source of increased visitation to zoos as baby animals can draw large crowds. Influential animal rights organizations, such as People for the Ethical Treatment of Animals (PETA), question the ethics of keeping animals in captivity, and characterize zoos as de-facto "prisons" for the animals on display (PETA, 2016). The treatment of zoo animals is also a matter of widespread public concern. In recent years, questions regarding improper exhibit maintenance, unsafe conditions for humans and animals, and enclosures too small for the animals have all been raised (Kirby, 2013; Mehaffrey, 2016; Walters, 2016). This type of criticism puts zoos in a difficult position in terms of animal captivity and breeding, which are two activities central to the conservation mission of many zoo organizations.

Historically public zoos purchased most of their animals; when breeding in captivity did take place, it was generally for the purposes of increasing the number of animals on exhibit, or to sell excess animals to other zoos (Rees, 2011). However, today captive breeding is considered an important tool to maintain genetic diversity for small populations and avoid the extinction of critically at-risk animals (Conde et al., 2015; Lacy et al., 2013; Owen and Wilkinson, 2014). Indeed, one of the first conservation initiatives promoted by zoos was captive breeding, where rare or threatened animals are bred for the purpose of reintroducing their descendants back into the wild (Barrows, 1997). Captive breeding can also be used to create assurance populations, which maintain genetic diversity through *ex situ* populations in case of a catastrophic event severely depleting the wild populations (Conde et al., 2015; Grant and Hudson, 2015; Taylor-Holzer et al., 2013). Other motivations for captive breeding include a desire to reduce the number of wild-caught animals in zoos and to provide research opportunities that would be impossible to conduct on wild animals (Fa et al., 2011; Pfaff, 2010).

Often captive breeding is paired with either a reintroduction program or a headstarting program. With the former, a species is bred in captivity for the purpose of releasing it into the wild. Conversely, headstarting is defined as "a conservation technique for improving survival of species with high juvenile mortality" and involves taking eggs or young animals from the wild, overwintering them during their first year when mortality levels are generally highest, and then reintroducing them back into the wild once that high mortality period has passed (Sacerdote-Velat et al., 2014, 1). In both cases – reintroduction and headstarting – zoos are contributing to the conservation of wild populations. However, come criticisms of these practices exist. For example, it has been argued that the removal of wild animals for captive breeding only harms the wild population more, reducing its ability to recover on its own (McCleery et al., 2014). Zoo captivity is also thought to be detrimental to the health of animals, leading to abnormal behavioral development (Morin, 2015), and resulting in animals being unfit for reintroduction (McPhee, 2003, Robert, 2009). While new styles of exhibit design endeavor to address this problem through making zoo enclosures feel more natural (Fa et al., 2011), it remains difficult to train a captive-bred animal for life in the wild (Banks et al., 2002; Carbyn et al., 1994; Griffin et al., 2000; Jule et al., 2008). Fortunately, many recent reintroduction efforts are taking steps to improve captive-bred animal behavior through special conditioning programs prior to reintroduction (Jachowski and Lokhart, 2009; Reading et al., 2013; Vilhunen, 2006).

It is important to note that captive breeding with reintroductions is not the only ways zoo participate in conservation. Instead, zoo organizations participate in education and training programs, habitat protection projects, research, and species protection, both *ex situ* and *in situ* (Gusset and Dick, 2010). Worldwide there is an estimated 700 million visitors to zoos each year (Gusset and Dick, 2011). As a result, the potential for zoos to educate and promote conservation is often seen as the most important role that zoos can play in conservation (Moss et al. 2015; Packer and Ballantyne, 2010). Indeed, there is significant literature examining education programs at zoos, including the relationship between zoo visits and attitudes toward zoos, animals, and conservation (see, for example, Carr and Cohen, 2011; Moss et al., 2015; Roe et al., 2014; Schultz and Joordens, 2014; Tribe and Booth, 2003).

However, there is less academic research into the ways zoos engage in species at risk conservation, especially in Canada. According to Gusset and Dick (2011), the world zoo community spent (at least) an estimated $350 million USD in 2008 on wildlife conservation. Many zoos spend conservation dollars on *in situ* and *ex situ* conservation projects (see Gusset and Dick, 2010). There is growing attention to the need for zoos to provide these projects to prevent biodiversity loss across the globe. Lacy et al. (2013) point out that zoos "have an expanding role and responsibility to contribute to species conservation amid this biodiversity crisis" (10). They argue that zoos must focus on both assurance populations at the zoo as well sustainable wild environments and populations for reintroduction programs (Lacy et al., 2013). There is no existing literature that

Table 1
Description of case studies; year of establishment and year of AZA accreditation.

Zoo	Date established	Date of AZA accreditation
Assiniboine Park Zoo	1904[a]	2014
Calgary Zoo	1929	1978
Toronto Zoo	1888[b]	1980[c]
Vancouver Aquarium	1956	1975

[a] Established in 1904 as the Winnipeg Zoo and became the Assiniboine Park Zoo in 2008.
[b] Established as the Riverdale Zoo in 1888 and became the Metro Toronto Zoo in 1974.
[c] The Metro Toronto Zoo held AZA accreditation from 1980 and 2012, but then lost that accreditation because the zoo's Board of Management voted to send zoo's elephants to a non-AZA accredited facility (Pagliano 2016) . In 2016 the zoo was formally re-accredited by AZA.

specifically addresses Canadian zoos participation in biodiversity conservation. Thus, this paper asks two related questions: First, *how* do Canadian zoos engage in species at risk (native and non-native) conservation through wildlife management practices? And second, *why* are Canadian zoos engaging in conservation of species at risk? If countries are serious about achieving their Aichi Targets, such as target 12, then more attention must be paid to the myriad of ways that the extinction of known threatened species can be prevented, and ways that the population of those species most in decline can be improved and sustained.

3. Methods

The World Association of Zoos and Aquariums (WAZA) is a global federation of accredited zoos. The goals of WAZA include promoting inter-zoo cooperation as well as encouraging "the highest standards of animal welfare and husbandry" within their member zoos (WAZA, 2016). More than 330 zoo and aquaria organizations from over 50 countries are WAZA members (WAZA, 2016). North American zoos have a more specialized governing organization, the Association for Zoos and Aquariums (AZA). Similar to WAZA, AZA dedicates most of its energy to ensuring high standards in animal care/management, conservation, and educational opportunities offered through its member zoos (AZA, 2016a,b). Of the 233 facilities accredited by AZA, only seven are located in Canada.[2] This paper presents research and interview data from four of these institutions: Assiniboine Park Zoo, Calgary Zoo, Toronto Zoo, and the Vancouver Aquarium. These are largest and oldest zoos and aquaria in Canada.[3] In total, there are about 100 zoos operating in Canada, but many of these are small wildlife collections (see Canadian Federation of Humane Societies N.d., 2017). There are 35 members of Canada's Accredited Zoos and Aquarium (CAZA) organization, which is a private charity operating in Canada since 1975 (see Canadian Association of Zoos & Aquariums, CASA, 2016). While the four case study zoos are not intended to be representative of all zoos in Canada, they are meant to provide an in-depth examination of CAZA and AZA accredited zoos in the country.

Canada was one of the first signatories to the United Nation's Convention on Biological Diversity in 1992, and the federal government ratified the treaty in 1993. There is a national Species at Risk Act, passed in 2002, that protects endangered, threatened, and special concern species throughout their range in Canada. An independent body of scientists, known as the Committee on the Status of Endangered Wildlife in Canada, assesses all native species to determine listing status. Today, there are over 500 species listed on the Species at Risk Act (see Canada, 2016). In 2010, Canada did commit to the United Nations Strategic Plan for Biodiversity 2011–2020, and is actively working toward the 20 Aichi Targets (see biodivcanada.ca). This is the first study to look at the role that Canadian zoos play in the conservation of species at risk, and it is also the first study to examine Canadian zoos from the inside – including site visits, interviews with zoo staff, and the collection of data on species at risk program occurring beyond the public eye (see Table 1).

A site visit was made to each zoo, which included interviews with zoo staff. Interviewees were contacted in a variety of ways. One co-author had previously worked at the Calgary Zoo and was able to directly contact the head of the conservation research department, who then arranged interviewees. At the Vancouver Aquarium and the Toronto Zoo, an email was sent to a known zoo researcher who helped arrange interviews. The Assiniboine Park Zoo requires researchers to go through the zoo's research review board, who evaluates the project and then determine participation. During the visits to the four different zoos, twenty-four interviews were conducted. The number of staff interviewed at each location was fairly consistent: seven at the Calgary Zoo, six at each Assiniboine and Vancouver, and five at the Toronto Zoo. The interviews lasted between twenty minutes to sixty minutes and each began with several general questions, as recommended by the pyramid method (Dunn, 2010). These questions were related to how long the individual had worked for the zoo, what their role

[2] Assiniboine Park Zoo, Calgary Zoo, Granby Zoo, Montreal Biodome, Toronto Zoo, Ripley's Aquarium of Canada, and the Vancouver Aquarium.
[3] The zoos in Quebec were excluded in this study because of language barriers, but future research will examine the role that Granby Zoo and Montreal Biodome play in the conservation of species at risk. Also, the Ripley's Aquarium of Canada was excluded because it was only established in 2015.

Table 2
Description of case study institutions species collection.

Zoo	Total species	Number of Canadian species	Number of at-risk species	Number of at-risk Canadian species
Assiniboine Park Zoo	200	34	23	6
Calgary Zoo	130	29	29	10
Toronto Zoo	460	44	82	15
Vancouver Aquarium	935	712	Data unavailable	Data unavailable

was there, and how conservation came into their job. Questions then focused more on the role of the institution in general, followed by inquiries into the current protections for species at risk in Canada. (In the next section, interviews are referenced and/or cited with a short designation for each zoo. AZ is the Assiniboine Zoo, CZ is the Calgary Zoo, TZ is the Toronto Zoo, and VZ is the Vancouver Zoo. The number following the abbreviation indicates which interview is referenced, such that, for example, AZ-3 denotes interviewee 3 at the Assiniboine Zoo. In some instances, follow-up phone calls or emails were sent to the interviewees in regard to a specific detail or clarification. These are cited as "personal communications" throughout the paper.)

The site visits also included participation observation of species-at-risk exhibits and the collection of promotional materials accessible at the zoos. If available, we obtained annual reports and budget information from zoo staff. This information was also found through zoo websites, which were carefully analyzed for information about the zoo collection, especially species at risk, as well as information about the structure and organization (governing) of each zoo. While there is little existing literature about Canadian zoos, we analyzed reports produced by AZA, CAZA, and the four case study zoos to verify and support interviewee data.

4. Results and discussion

The four institutions vary in species collection size. As Table 2 illustrates, the Calgary Zoo is the smallest, with only about 130 total species. In terms of the number of native species, the Vancouver Aquarium dwarfs the other zoos with a total of 712 Canadian species inside its collection. Unfortunately, data on the number of International Union for Conservation of Nature (IUNC) listed species at risk and Canadian listed species at risk was not available for the Vancouver Aquarium. On its website, the Vancouver Aquarium features its conservation mission and explains its "animal protection program" for endangered species, namely the Oregon Spotted Frogs, Leatherback turtles, Killer whales, and rockfish (see Vancouver Aquarium N.d., 2017). And the website also features information about the research conducted at the zoo in relation to vulnerable and at-risk populations. Thus, while the exact number of at-risk species housed at the zoo is unknown, it is clear (from interviews and grey literature), that the Vancouver Aquarium collection does include Canadian at-risk populations. As Table 2 illustrations, the other institutions are home to numerous at risk species, and each also contain between six and fifteen Canadian (federally or provincially) listed species at risk.

Through the interview process and data collection, we learned that each institution is engaged in hands-on conservation of species at risk in three main ways: captive breeding, reintroduction, and headstarting programs. The results are organized into these subsections. While these zoos are also involved in education and research in relation to biodiversity conservation, that is not the main focus of this paper. The last subsection investigates why zoos participate in wildlife management for conservation of species at risk from the perspective of staff working at the four institutions.

4.1. Captive breeding

Since the earliest days of publicly exhibited captive animals, zoos have been breeding species in order to maintain their zoological collections (Rees, 2011, Interview CZ-7). While the practice of breeding animals for exhibit maintenance and education is still certainly occurring (InterviewVZ-4), these four zoos appear to be moving toward restricting their captive breeding activities to focus on breeding animals for conservation (Interview CZ-7). Conservation-aligned captive breeding programs at the four study institutions are coordinated by outside organizations, mainly through international AZA Species Survival Plans (SSPs), the European Endangered Species Program (EEP), or through local government initiatives. Both the SSPs and EEP coordinate breeding efforts across multiple zoos through the use of studbooks, which keep track of parentage and determine the best breeding partners for individuals in a given species. Table 3 illustrates zoo participation in breeding, reintroduction, and headstarting programs. In the case of breeding programs, these refer to programs managed by either the SSP or EEP.

Beyond international breeding initiatives, all four zoos are playing a part in federally-based species at risk recovery efforts. In total, there are 33 federally listed species at risk in Canada whose current recovery strategy or management plan references the involvement of zoos. Of these 33 documents, six of them include a current captive breeding component[4] and two other recovery documents mention the potential of captive breeding to assist in the recovery of the species[5] . Habitat protection is

[4] Whooping crane (*Grus Americana*), Oregon spotted frog (*Rana pretiosa*), Blanding's turtle (*Emydoidea blandingii*), Massasauga rattlesnake (*Sistrurus catenatus*), swift fox (*Vuples velox*), black footed ferret.

[5] Sand darter (*Ammocrypta pellucida)* and Greater sage grouse *(Centrocercus urophasianus)*.

Table 3
Zoo participation in breeding, reintroduction, and headstarting programs.

Zoo	Total species	Number of species in breeding programs	Number of reintroduction programs	Number of headstarting programs
Assiniboine Park Zoo	200	50	1	1
Calgary Zoo	130	45	5	1
Toronto Zoo	460	122	8	2
Vancouver Aquarium	935	8	2	0

usually the first objective in federal recovery strategies; indeed, the identification of critical habitat and mitigation of threats to it are mandatory components to species recovery in Canada (Canada, 2016). In cases like the six aforementioned species, populations in the wild were so low that simply conserving habitat and encouraging natural breeding in the wild would not be enough. The Vancouver Island marmot,[6] for instance, experienced a 50% decline in its wild population from 1997–2007, 80% of which was caused by predation events (Canada, 2016). These dramatic decreases in the wild population spurred the need to begin a captive breeding and reintroduction program. Presently the Calgary Zoo and the Toronto Zoo continue to provide such programs (Interview TZ-3). In 2015 it was estimated that 250–300 marmots live in a handful of colonies on 28 mountains in British Columbia as a result of zoo-led recovery efforts (Marmot Recovery Foundation N.d., 2017).

Provincial recovery efforts are also beginning to recognize the potential of captive breeding in restoring species with extremely low populations. Seven of Ontario's published provincial recovery strategies or management plans include captive breeding. For two of these plans (piping plover[7] and peregrine falcon[8]), captive breeding efforts have already been used to successfully increase population numbers, with the Toronto Zoo taking an active role in breeding peregrine falcons (Kirk, 2013; Ontario Peregrine Falcon Recovery Team, 2010). Five other recovery plans mention the need to evaluate whether captive breeding is possible for the species, and how it could be accomplished, (Morris, 2010, 2011; Ontario Ministry of Natural Resources, 2013a,b,c).

In Alberta, there are four current recovery strategies that include a captive breeding component[9] (Alberta Environment and Sustainable Resource Development, 2012, 2013; Alberta Peregrine Falcon Recovery Team, 2005, Alberta Swift Fox Recovery Team, 2007). All four of these strategies have received input and participation from the Calgary Zoo, although the zoo itself is not currently involved in the breeding of northern leopard frogs (Interview CZ-2). However, the Vancouver Aquarium is the primary breeding facility for northern leopard frogs, and works with the Calgary Zoo on the northern leopard frog project in both Alberta and British Columbia (Interview CZ-2). While it is too early to judge the success of this program, the Vancouver Aquarium has successfully produced tadpoles and released thousands into the wild (Mangione, 2016).

Like Alberta, the government of British Columbia also has four provincial recovery documents that mention captive breeding[10] (British Columbia Invertebrates Recovery Team, 2008, Canadian Oregon Spotted Frog Recovery Team, 2014, Northern Leopard Frog Recovery Team, 2012, Vancouver Island Marmot Recovery Team, 2008). Though the Puget Oregonian snail recovery team is still in the process of determining whether captive breeding is a viable strategy for this species (British Columbia Invertebrates Recovery Team, 2008), the other three species have current captive breeding programs occurring at the Vancouver Aquarium, the Calgary Zoo, and Toronto Zoo (Interview VA-3, VA-4, CZ-1, TZ-3).

While three of the four provinces in which the zoos are located have their own recovery strategy procedures, Manitoba does not. Manitoba introduced legislation mandating the development of provincial local recovery plans in 2012 (Manitoba Wildlife Branch, pers. comm., May 9 2016). However, due to the recent nature of this legislation and the time intensive process required to develop full recovery plan, the government of Manitoba has not yet been able to formally publish any recovery strategies, save for woodland caribou (Manitoba Wildlife Branch, pers. comm., May 9 2016). As they work on developing new recovery strategies, the provincial government has continued their former practice of adopting the federal recovery plans for any species occurring in the province (Manitoba Wildlife Branch, pers. comm., May 9 2016). Of these, two (the burrowing owl and peregrine falcon) include captive breeding components (Environment Canada 2012, 2015). The Assiniboine Park Zoo currently is assisting the provincial government with the burrowing owl captive breeding program by providing genetic analysis to recommend pairings and housing the owls during the breeding process (Interview AZ-5).

4.2. Captive breeding with reintroduction

While captive breeding is an important part of the role of Canadian zoos in species at risk protection and recovery efforts, most interviewees ($n = 20$) felt that zoos should also be involved in reintroduction efforts, and that "putting animals back" into the wild was a good fit for zoos (Interview CZ-6). All four of the case study institutions are involved in reintroduction programs (see Table 3), which focus almost exclusively on native species; as several interviewees stated,

6 *Marmota vancouverensis*.
7 *Charadrius melodus*.
8 *Falco peregrinus*.
9 The leopard frog (*Lithobates pipiens*), greater sage grouse, peregrine falcon, and swift fox.
10 Puget Oregonian snail (*Cryptomastrix devia*), Oregon spotted frog, the northern leopard frog, and the Vancouver Island Marmot.

Table 4
Current reintroduction programs at the case study institutions.

Assiniboine Park Zoo	Calgary Zoo	Toronto Zoo	Vancouver Aquarium
Burrowing Owl	Whooping Crane	Puerto Rican Crested Toad	Oregon Spotted Frog
	Vancouver Island Marmot	Eastern Loggerhead Shrike	Rockfish
	Greater Sage Grouse	Vancouver Island Marmot	Northern leopard frog
	Burrowing Owl	Black-footed Ferret	
	Swift Fox	Trumpeter Swan	
		Blanding's Turtle	
		Wood Turtle	
		Oregon Spotted Frog	

there is a local species focus for reintroductions due to the need to protect what is in their own backyards (Interview CZ-2, AZ-1), and because focusing on local conservation efforts is a more efficient use of resources (Interview CZ-2, TZ-1). For example, Vancouver's "protecting animal program" mentioned above includes only species native to Canada and includes reintroduction programs for 3 of these species (Vancouver Aquarium nd.). The one notable exception to the native species focus is the Puerto Rican Crested Toad[11] program at the Toronto Zoo, which not only involves breeding and reintroductions, but also a large amount of community outreach and education in Puerto Rico (Interview TZ-2). Table 4 illustrates the active reintroduction-based programs at the case study institutions.

The Calgary Zoo runs a high-profile whooping crane project. It is the only Canadian breeding facility and works in conjunction with US breeding facilities. Crane numbers hit their lowest point in 1941, with just 15 wild individuals found (Canada, 2016). Today, there are four wild flocks (Kelly Swan, pers. comm. May 10 2016) spread across the United States and Canada, three of which are now reproducing in the wild. The Wood Buffalo and Eastern Migratory flocks have both increased in population, to 329 and 105 individuals respectively (Buttler and Harrell, 2016, Whooping Crane Eastern Partnership, 2016). The Louisiana flock, which is fully made up of reintroduced individuals, sits at an estimated 46 individuals (Kelly Swan, pers. comm. May 10 2016); this year also saw the first crane chicks born in the wild in Louisiana since 1939 (McConnaughey, 2016). Without the participation of the Calgary Zoo it is not clear if the Whooping Crane story would be such an overwhelming success.

The Calgary Zoo also participates in an ongoing and successful swift fox project. Native to Alberta, Saskatchewan, and Northern Montana, the swift fox experienced rapid population declines following the settlement of the North American prairies, leading to their eventual extirpation from Canada in 1978 (Pruss et al., 2008). After reintroductions began in the 1980s, the swift fox was down-listed from "extirpated" to "endangered" in 1998 (COSEWIC, 2011). Further reintroductions and monitoring by the Swift Fox Recovery Team, of which the Calgary Zoo is a member, resulted in the swift fox being further down-listed to "threatened" in 2009 (COSEWIC, 2011). A search of the COSEWIC Species at Risk database found that the swift fox is one of only six species in Canada to have ever been down-listed; a direct result of successful reintroduction efforts (Interview: CZ-1).

Both the Calgary Zoo and the Vancouver Aquarium participate in the northern-leopard frog reintroduction project in British Columbia (CZ-2, VZ-3, VZ-4). In 2014, over 2000 captive bred tadpoles were reintroduced to the wild (Kootenay Conservation Program, 2014); however, monitoring the introduced populations will continue to occur for several more years before the program can be declared a success or not (Kootenay Conservation Program, 2014). The Vancouver Island marmot (Calgary Zoo and Toronto Zoo), Blanding's turtle (Toronto Zoo), and burrowing owl (Assiniboine Park Zoo) projects are all in similar situations; although some reintroductions have occurred, it is still too early to tell whether or not those efforts have been successful.

Not all reintroduction programs offered by these zoos have been success stories. The black-footed ferret reintroduction program in Grasslands National Park (Saskatchewan) carried out by the Toronto Zoo was one such effort. Formally thought to be extinct, a small population of black-footed ferrets was found in Wyoming in 1981 (Jachowski and Lokhart, 2009). The wild ferrets were then brought into captivity, bred in several facilities (including the Toronto Zoo) and successfully reintroduced to several different sites in the United States and Mexico (Jachowski and Lokhart, 2009). However, efforts to restore black-footed ferrets to Canada experienced some serious complications (Interview TZ-3). One year after the original group of ferrets was introduced to Grasslands National Park in 2009, plague arrived at the reintroduction site, devastating the prairie dog populations in the area (Interview TZ-3). The black-footed ferret diet is almost exclusively (87%–91%) black-tailed prairie dogs[12] (Barrows, 1997); thus, the dramatic decrease in the prairie dog populations led to the assumed demise of all of the reintroduced ferrets (Interview: TZ-3). Although staff from the Calgary Zoo, Toronto Zoo, and Parks Canada continue to survey the area for ferrets, none have been sighted since 2013 (Interview: TZ-3).

In other cases, even though a captive breeding program may be designed with a reintroduction component in mind, it is not always possible to restore the species to its native habitat. For instance, the widespread distribution of chytrid fungus, which releases a pathogen that destroys an amphibian's ability to respire through their skin (Skerrat et al., 2007), now covers

11 *Bufo lemur*.
12 *Cynomys ludovicianus*.

the entirety of the native range for the Panamanian Golden Frog[13] (Interview VA-4). Both the Vancouver Aquarium and the Toronto Zoo are breeding populations of Panamanian golden frogs; however, the continued presence of the chytrid fungus in the animal's range means that no reintroductions of the species can take place until this threat has been mitigated (Toronto Zoo, 2016a,b). Although reintroductions may not always be possible using a captive-bred population, 25% of interviewees ($n = 6$) mentioned that it was still worthwhile for zoos to breed animals, as the captive assurance populations provide a reserve of genetic material in case of a catastrophic event in the wild populations.

4.3. Headstarting

While conducting the interviews, many of the participants ($n = 10$) explained how their zoo was involved in headstarting programs (see Table 3). The Toronto Zoo focuses their headstarting efforts on Blanding's turtles in the Rouge Valley National Park and wood turtles[14] in other parts of Ontario (Interview TZ-2). Both of the Toronto Zoo headstarting programs involve partnering with other agencies, including Parks Canada and the Ontario Ministry of Natural Resources, to remove eggs from the wild, hatch and raise the young at the zoo, and then release the young turtles into protected sites (Interview TZ-2). In the case of the Blanding's turtle, headstarting was a high priority, as there were only an estimated six turtles remaining in the Rouge Valley area prior to the establishment of the headstarting program (Toronto Zoo, 2016b). The first headstarted Blanding's turtles were collected as eggs from stable populations in other parts of Ontario (Toronto Zoo, 2016b). After being hatched, the juvenile turtles spent two years in captivity while they grew to a large enough size to reduce the risk of predation (Toronto Zoo, 2016c). The first round of 10 headstarted turtles was released in the Rouge Valley park in 2014, and this project is anticipated to continue until 2024, with several more rounds of reintroductions planned and a monitoring program already in place to evaluate the success of the headstarting project (Jivov, 2014, Interview: TZ-2).

The Calgary Zoo and Assiniboine Park Zoo are both involved in headstarting efforts for burrowing owls in British Columbia and Manitoba respectively (Interview CZ-3, CZ-5, AZ-2, AZ-5). Though the Calgary Zoo's burrowing owl headstarting program is still in the planning stages, the Assiniboine Park Zoo has been involved with burrowing owl recovery since 2010, and is a founding member of the Manitoba Burrowing Owl Recovery Program (MBORP) (Assiniboine Park Zoo, 2016). The Assiniboine Park Zoo is responsible for housing the owls (in a non-public area) over the winter, in addition to conducting all of the genetic testing and deciding which headstarted owls should be paired together in order to foster the greatest possible genetic diversity (Assiniboine Park Zoo, 2016 , Interview AZ-5). Unfortunately, the Manitoba burrowing owl project has experienced some setbacks since headstarting began, including several years where flooding wiped out the nest site areas (Interview: AZ-5). The relatively small number of possible reintroduction sites in the province is also an issue; if something happens to the existing reintroduction sites, there are few other places where it would be appropriate to release the owls (Interview: AZ-5).

4.4. Why participate –opportunities & challenges

Over the course of the interviews, the zoo staff members were asked why they thought their institution was participating in captive breeding/reintroduction programs. Responses to this question were generally in agreement with the idea that zoos have the space and the expertise to do so, as discussed by over half ($n = 13$) of the participants. In particular, staff from the Calgary Zoo brought up the existence of the zoo's Devonian Wildlife Conservation Centre (DWCC) (Interview CZ-2, CZ-5, CZ-7), which is located in a rural area outside of the city and is not open to the public (Calgary Zoo, 2015). This space is exclusively used for breeding animals for the zoo's conservation programs (Interview CZ-5, CZ-7), including animals that require large amounts of space, such as the zoo's herd of Przewalski's horses (Calgary Zoo, 2015). The existence of the DWCC increases the Calgary Zoo's ability to participate in breeding programs, and the amount of non-public space dedicated to conservation helps to distinguish them from other organizations (Interview: CZ-7).

Expertise was also felt to be a major advantage for zoos, many respondents ($n = 15$) citing experience with keeping and breeding animals as one of the most important factors to why zoos were involved with breeding and reintroduction programs. When captive breeding programs become necessary for the recovery of a species, it follows that the people in charge of coordinating the breeding program be experts on keeping animals in captivity. However, even though the people coordinating zoo captive breeding programs are experts, there are challenges associated with zoo-led breeding and reintroduction efforts that can affect the success of the programs.

First, a lack of space was felt to be a challenge by staff members from two of the case study institutions (Interview VZ-3, VZ-4, TZ-4). In particular, the non-exhibit space at the Vancouver Aquarium is quite restricted, and limits the ability of the facility to participate in large-scale breeding or reintroduction programs (Interview VZ-3, VZ-4). The institution's response to the restricted space problem has been to concentrate breeding efforts on smaller species (amphibians in particular) that are more easily housed; however, even these species programs are limited by space. While the aquarium is currently breeding both northern leopard frogs and Oregon spotted frogs, the facility staff would like to see the frogs kept for a longer period of time instead of being released as soon as they reach the tadpole morph (VZ-3, VZ-4). Tadpoles have a much higher mortality rate than adult frogs, mainly due to higher predation levels at the tadpole stage (Berven, 1990) and increased exposure to

13 *Atelopus zeteki*.

14 *Glyptemys insculpta*.

pesticide runoff, which can have detrimental effects on their development and behavior (Bridges, 2000). By holding off on the release of individuals until they had fully metamorphosed, survival rates would likely be much higher; nevertheless, the aquarium simply does not have the space or the resources to support large numbers of adult frogs (Interview VZ-3, VZ-4).

A second challenge is the need to address two contradictory components: the need to keep animals away from humans so that they do not become habituated (Griffin et al., 2000), and yet encourage the public to see conservation programs in action so that they are more inclined to support them (Interview: CZ-2, TZ-1). For instance, although the Calgary Zoo is the only Canadian breeding facility for whooping cranes, few members of the public are aware of this, as the whooping crane breeding takes place at the non-public DWCC. Whooping cranes can imprint on humans, which makes it very difficult to raise them in captivity while ensuring that they are still able to be successfully reintroduced. To combat this, whooping cranes at breeding centers such as the Calgary Zoo's DWCC are kept away from humans; the only contact they have with keepers is when the staff are dressed in crane costumes, a technique called "costume-rearing" (Urbanek et al., 2010).

Third, zoos that have the space and the expertise cannot save species at risk through headstarting or reintroductions if there is not habitat protect in the wild. Zoos have demonstrated that headstarting can be a valuable tool to increase the populations of species with high juvenile mortality rates, but equal emphasis must be placed on habitat preservation if the program is to succeed long-term (Heppell et al., 1996). Lastly, zoos are continually challenged by a lack of stable funding. Funding for conservation and research projects in general is a serious limitation for all four case study institutions. The interviews with zoo staff suggest that without more long-term funding from secure sources, it is highly unlikely that the case study institutions will be able to expand their involvement in conservation programs.

5. Conclusion and future research

Aichi Target 12 addresses the critical need to prevent the extinction of biodiversity and reverse population declines so that imperiled species can be sustained if not improved. This paper sought to examine how and why four AZA accredited Canadian zoos engage in wildlife management for the purposes of species at risk conservation. Using a case study approach and going inside the zoos to conduct research and interviews, we found that captive breeding, reintroductions, and headstarting projects are all a large component of conservation programming at the zoos. Each zoo is participating in 8–50 species breeding programs. These efforts are contributing to international breeding initiatives, such as the AZA Species Survival Plans and the European Endangered Species Programs, which coordinate breeding to maintain species' genetic diversity. The zoos, with the exception of the Assiniboine Zoo, are also participating in breeding efforts for listed Canadian species at risk. At both the federal level and the provincial level, governments are working with zoos to breed endangered and threatened species in zoos. This is a significant and understudied finding with regard to both species at risk policy and zoo conservation in the country.

All four zoos are also breeding wildlife for the purposes of reintroducing individuals into the wild — in hopes of increasing the wild population of the species. In total, the zoos participate in programs for 15 Canadian species at risk and 1 non-native species at risk. Zoos in Canada are working collaboratively across provincial and federal borders, engaging with governments and non-governmental organizations outside of their home provinces to protect and recover Canadian species. The successes of the whooping crane and swift fox reintroduction programs suggest that zoos could make a significant and critical contribution to the survival of wild native species in Canada, and should continue their involvement in captive breeding efforts for the sake of species recovery. Lastly, headstarting programs exist at the four zoos and are experiencing some success at reversing population declines in the wild. For example, the Blanding Turtle in Ontario may be brought back from critically endangered numbers by the Toronto Zoo's headstarting program (run in collaboration with Parks Canada and the Ontario government).

When zoos staff were asked why their zoo participates in conservation activities, there was strong consensus that zoos can offer two critical components: space and expertise. Many zoos have space on or off site to breed wild animals and/or keep them away from human beings such that human-imprinting does not occur during the headstarting process. Moreover, zoos are also staffed by wildlife experts who are able to assist in the breeding and reintroduction of animals. In this way zoos offer a unique setting for both the study and practice of wildlife conservation.

This paper has examined only four Canadian zoos. More research is needed to examine other zoos in Canada as well as other zoos throughout the world. It not clear the extent to which other accredited zoos in Canada, including the 31 other members of CAZA, are involved in biodiversity conservation, and comparative data would be beneficial to global the conservation society. There are 330 WAZA zoos globally –in countries like Columbia, France, Japan, Australia, Dubai, and Chile, for example. These zoos have committed to the conservation of biodiversity. It is likely that similar to Canadian zoos, these other WAZA member institutions are engaging in a myriad of critical conservation programs for native and non-native species at risk (see Gusset and Dick, 2010). We need a better understanding of the types of conservation activities occurring, and the ways in which zoos are working independently and together to protect and recover global biodiversity.

It has been noted that despite research into zoo's contribution to research and education, "zoos are still seen by some as being superficial, expensive, ineffective, and, therefore, indefensible" (Tribe and Booth, 2003, 66). This paper argues to the contrary. There can be little doubt that accredited zoos in Canada play a vital role in the recovery of species at risk. The work zoos are doing with captive breeding, reintroduction, and headstarting is expensive, but not superficial or ineffective. The Aichi Targets remain an ambitious achievement. The world is more than half way through the United Nations "decade on biodiversity", which was set as 2011–2020. Globally, governments and civil society must recognize that "zoo work still remains a grossly underutilized resource for the conservation of endangered species" (Mallinson, 2003).

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