PROPOSED

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Management Plan Series

Management Plan for the Eastern Wolf (*Canis lupus lycaon*) in Canada

Eastern Wolf

2017

Government of Canada
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For copies of the management plan, or for additional information on species at risk, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the Species at Risk Public Registry.[1]

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MANAGEMENT PLAN FOR THE EASTERN WOLF (*Canis lupus lycaon*) IN CANADA

2017

Under the Accord for the Protection of Species at Risk (1996), the federal, provincial, and territorial governments agreed to work together on legislation, programs, and policies to protect wildlife species at risk throughout Canada.

In the spirit of cooperation of the Accord, the Government of Ontario and the Government of Québec provided comments in the development of the Eastern Wolf Management Plan.

As of June 15, 2016, in Ontario only, the Eastern Wolf was re-assessed as the Algonquin Wolf. The Algonquin Wolf was up-listed as threatened under the Ontario's *Endangered Species Act*, *2007* which requires Ontario to develop a recovery Strategy by 2018. As the requirements under Ontario's *Endangered Species Act, 2007* are different than those under the federal Species at Risk Act, for information please refer to the following website (https://www.ontario.ca/laws/statute/07e06) or contact the Ontario Ministry of Natural Resources and Forestry at: recovery.planning@ontario.ca

Preface

The federal, provincial, and territorial government signatories under the Accord for the Protection of Species at Risk (1996)[2] agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c. 29) (SARA), the federal competent ministers are responsible for the preparation of management plans for listed species of special concern and are required to report on progress within five years after the publication of the final document on the Species at Risk Public Registry.

The Minister of Environment and Climate Change and Minister responsible for the Parks Canada Agency is the competent minister under SARA for the Eastern Wolf and has prepared this management plan, as per section 65 of SARA. To the extent possible, it has been prepared in cooperation with the governments of Ontario and Quebec, as per section 66(1) of SARA.

Success in the conservation of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this plan and will not be achieved by Environment and Climate Change Canada and the Parks Canada Agency, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this plan for the benefit of the Eastern Wolf and Canadian society as a whole.

Implementation of this management plan is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

[2] http://registrelep-sararegistry.gc.ca/default.asp?lang=En&n=6B319869-1%20

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The first drafts of this management plan were prepared by John Benson (Environmental and Life Sciences Program, Trent University) and Karen Loveless (Montana Department of Fish, Wildlife and Parks) with the assistance of Linda Rutledge (Trent University) and Brent Patterson (Ontario Ministry of Natural Resources and Forestry). The initial contributions of Madeline Austen, Paul Watton and Angela McConnell (Canadian Wildlife Service – Ontario Region), Susan Humphrey, Barbara Slezak and Kari Van Allen (formerly with the Canadian Wildlife Service – Ontario Region), Greg Wilson (Canadian Wildlife Service – Prairie and Northern Region), Paul Johanson, Wendy Dunford and Véronique Brondex (Canadian Wildlife Service – National Capital Region), Denis Masse, Sylvain Paradis and Claude Samson (Parks Canada Agency), Brad Allison, Maria de Almeida, Amelia Argue, Patrick Hubert, Al Hyde, Lauren Krushenske, Donald Lewis, Kathryn Markham, Brian Naylor, Bruce Ranta, Chris Risley and Jim Saunders (Ontario Ministry of Natural Resources and Forestry), Sandy Dobbyn, Paul Gelok, Jennifer Hoare and Ed Morris (Ontario Parks), Michel Hénault, Antoine St-Louis and Nathalie Tessier (Quebec Department of Forests, Wildlife and Parks [MFFP]), Astrid Vik Stronen (University of Montreal) and Hélène Jolicoeur and Mario Villemure (independent) are also acknowledged and appreciated.

Executive Summary

The Eastern Wolf (*Canis lupus lycaon*) is listed as a species of special concern under Schedule 1 of the *Species at Risk Act* (SARA), which requires the drafting of a management plan. The taxonomic status of the Eastern Wolf has been a subject of debate, and recent progress in genetic research has led to a better understanding of the origins of several species and hybrids of the genus *Canis* in North America. These new genetic analyses indicate that the Eastern Wolf is not a subspecies of the Grey Wolf (*Canis lupus lycaon*). In May 2015, the Eastern Wolf was recognized as the species *Canis* sp. cf. *lycaon* and was designated Threatened by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2015). This management plan also considers the Eastern Wolf as a distinct species. However, it is important to note that the legal status of the species under SARA remains “Special Concern” until a decision is taken by the Governor in Council to change the legal status of the species.

Historically, the Eastern Wolf inhabited the deciduous forests of the eastern United States and southeastern Canada. According to current knowledge, it is believed that the Eastern Wolf is present in certain parts of central Ontario and southern Quebec, but owing to the intensive hybridization of the Eastern Wolf with the Coyote (*Canis latrans*), the Grey Wolf (*Canis lupus*) and hybrids of the genus *Canis*, the limits of its range are difficult to determine. Hence, the distribution of hybrid individuals that have Eastern Wolf genetic material (i.e., “Great Lakes–Boreal Wolf” [*C. lupus* x *C.* sp. cf. *lycaon*] and “Eastern Coyote” [*C. latrans* x *C.* sp. cf. *lycaon*]) could extend westward in Canada to certain parts of Manitoba and Saskatchewan and eastward to New Brunswick, as well as to parts of Minnesota, Michigan and Wisconsin in the United States. Recent genetic research suggests that the Eastern Wolf may be closely related to the Red Wolf (*Canis rufus*), an endangered species in the southeastern United States.

Over the course of its life, Eastern Wolf uses various types of habitats. It is generally found in extensive forested areas (e.g., over 100 km^2). Eastern Wolf populations are limited by prey availability, and higher densities are observed in areas with high prey abundance, particularly White-tailed Deer (*Odocoileus virginianus*), Moose (*Alces alces*) and Beaver (*Castor canadensis*). Hybridization of the Eastern Wolf with the Grey Wolf is also considered a limiting factor, as is the territoriality of large canid packs, which reduces the potential expansion of the Eastern Wolf population beyond already occupied sites.

The main threats to the Canadian Eastern Wolf population include, but are not limited to hunting, trapping and poaching, roads, and hybridization with the Eastern Coyote. The impact of other threats is considered low to negligible (e.g., residential and commercial development, agriculture and recreational activities) or as yet unknown (e.g., diseases and parasites associated with other animals and changes in habitats and availability of prey induced by climate change).

The management objective is to achieve and maintain a viable Eastern Wolf population within the species' current Canadian range. To achieve this management objective, the density of the Eastern Wolf population in the Algonquin Provincial Park area will have to be maintained, at a minimum, at the current level, which is estimated at approximately 2.1 individuals per 100 km^2, and the presence of the species at other sites within the Canadian area of occupancy will have to be preserved. Connectivity between the occupied sites and other regions where suitable habitat is found must also be ensured to facilitate dispersal of individuals and maintain genetic cohesion of the species in Canada. Additional research will be required to improve understanding of the Eastern Wolf's distribution, abundance and effective population size, to identify connectivity requirements, to clarify taxonomic uncertainties and to manage technical challenges associated with the need to identify the species through molecular analyses. When the success of the plan is assessed, the management objective may be re-examined in light of this new information.

Four broad strategies and a number of conservation measures are proposed in order to achieve the objective of this management plan. Although some of them may have a positive or negative effect on other species, it may be possible to reduce or mitigate any negative effects by adopting an ecosystem approach when implementing the species management activities.

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1. COSEWIC* Species Assessment Information

Date of Assessment: May 2001

Common Name: Eastern Wolf

Scientific Name: *Canis lupus lycaon*

COSEWIC Status: Special concern

Reason for Designation: This wolf may be a separate species.Its exact range is not known, partly because it hybridizes with grey wolves. Although there is no evidence of decline in either number or geographic range over the last 20 years, it may be undergoing hybridization with coyotes, possibly exacerbated by habitat changes and high levels of harvesting. Identification of this taxon requires a molecular analysis.
Canadian Occurrence: Ontario, Quebec

COSEWIC Status History: Designated Data Deficient in April 1999.
Status re-examined in May 2001 and designated Special Concern.

Date of Assessment: May 2015 (In a higher risk category)

Common Name: Eastern Wolf

Scientific Name: *Canis* sp. cf. *lycaon*[3]

COSEWIC Status: Threatened

Reason for Designation: This species is an intermediate-sized canid with a generally reddish-brown/tawny coat. It has a small population size (likely < 1,000 individuals) and a restricted range, limited to south-central Ontario and south-central Quebec. Most records come from scattered protected areas, where mortality and rates of hybridization with Eastern Coyotes occurs less frequently than elsewhere in its range. Population expansion is unlikely, owing to competition with Eastern Coyote and increased mortality rates outside protected areas.

Canadian Occurrence: Ontario, Quebec

COSEWIC Status History: In 1999, the Eastern Grey Wolf (*Canis lupus lycaon*) was considered a subspecies of the Grey Wolf and was placed in the Data Deficient category. Status was re-examined (as Eastern Wolf, *Canis lupus lycaon*) and designated Special Concern in May 2001. New genetic analyses indicate that the Eastern Wolf is not a subspecies of Grey Wolf. In May 2015, a new wildlife species, Eastern Wolf (*Canis* sp. cf. *lycaon*) was designated Threatened and the original designation was deactivated.

* COSEWIC (Committee on the Status of Endangered Wildlife in Canada)

[3] The abbreviation “sp. cf.” in the scientific name means that the Eastern Wolf is recognized as a distinct species based on the best available data, while taking into account that the current taxonomic debate has not yet been completely resolved.

2. Species Status Information

The global conservation status of the Eastern Wolf (*Canis lycaon*) is not ranked, as NatureServe identifies the Eastern Wolf as a subspecies of the Grey Wolf (*Canis lupus*), i.e., *Canis lupus lycaon*, and recognizes *Canis lycaon* as a synonym (NatureServe 2017). In Canada, the national conservation status is Apparently Secure (N4), and the provincial conservation status is Apparently Secure (S4) in Ontario and Unranked (SNR) in Quebec (NatureServe 2017). In the United States, data on its distribution are incomplete or have not been examined for this taxon (NatureServe 2017).

The Eastern Wolf (*Canis lupus lycaon*) is listed as a species of special concern[4] in Schedule 1 of the *Species at Risk Act* (SARA) (S.C. 2002, c. 29). In May 2015, COSEWIC designated the Eastern Wolf as a distinct species and uplisted it to a higher risk category, i.e., threatened. As a result of this reassessment and change in risk category, the species will be eligible for an amendment of its status under Schedule 1 of SARA. In January 2016, the Committee on the Status of Species at Risk in Ontario (COSSARO) reassessed the taxon formerly recognized as "Eastern Wolf (*Canis lupus lycaon*)" as "Algonquin Wolf (*Canis* sp.)" and reassessed it as "Threatened" (COSSARO 2016). In June 2016, the Ontario government listed the Algonquin Wolf (*Canis* sp.) as Threatened[5] under the Ontario *Endangered Species Act, 2007* (S.O. 2007, c. 6). In Quebec, only the Grey Wolf (*Canis lupus*) is officially recognized by the provincial government and this species is not listed under the Quebec *Act respecting threatened or vulnerable species* (C.Q.L.R., c. E-12.01).

In this document, the Eastern Wolf will be considered a distinct species, in accordance with the most recent COSEWIC status report on the species (COSEWIC 2015). In the status report, the Eastern Wolf is defined by a combination of morphological[6] characteristics, its ecological role and specific genetic characteristics (COSEWIC 2015).

3. Species information

3.1 Species History

Eastern Wolves have long been recognized as being morphologically distinct from Grey Wolves (Young and Goldman 1944; Kolenosky and Standfield 1975) as they are slightly smaller and have a lower body mass than Grey Wolves. Aboriginal traditional knowledge from the Mohawk First Nation of Akewesasne notes that more than one type of canid was recognized in the region before European contact, based on differences in body size, temperament and size of prey (Lickers, pers. comm. 2015, in COSEWIC 2015). The historical range of the Eastern Wolf likely covered a large part of

[4] A wildlife species that could become threatened or endangered because of a combination of biological characteristics and identified threats.
[5] A species that lives in the wild in Ontario, is not endangered, but is likely to become endangered if steps are not taken to address factors threatening it.
[6] The size, shape and structure of an organism or of one of its parts.

northeastern North America (COSEWIC 2015; see section 3.3 *Species Population and Distribution*).

There has been some debate in the literature as to whether the Eastern Wolf is the result of historical hybridization between the Coyote (*Canis latrans*)[7] and the Grey Wolf (*Canis lupus*; Lehman et al. 1991; Roy et al. 1994; Wayne and Vila 2003, cited in Kyle et al. 2006),[8] an ecotype or population of the Grey Wolf (Koblmüller et al. 2009), or a completely distinct wolf species (Wilson et al. 2000; Kyle et al. 2006; Rutledge et al. 2012). Recent genetic research (e.g., Wilson et al. 2000, 2003, 2009; Rutledge 2010a; Rutledge et al. 2010b, 2010c, 2012; vonHoldt et al. 2011; Benson et al. 2012; Rutledge et al. 2015) and the lack of evidence of hybridization between the Coyote and the Grey Wolf (Mech 2011) strongly suggest that the Eastern Wolf is not a subspecies of the Grey Wolf, nor a hybrid, but rather a distinct species.[9] In keeping with the COSEWIC status report (2015), the latter classification was used in this management plan (see Appendix 1 of the status report for further details). According to this definition, the Gray Wolf–Eastern Wolf hybrid is called the “Great Lakes–Boreal Wolf” (*C. lupus* x *C.* sp. cf. *lycaon*), and “Eastern Coyote” (*C. latrans* x *C.* sp. cf. *lycaon*), which is sometimes also called “coywolf” (Way et al. 2010), is the name used for the Eastern Wolf–Coyote hybrid. The Eastern Coyote is widespread in southern Ontario and Quebec and in the Atlantic provinces (Way 2007; Way et al. 2010; NLDEC 2016).

However, on the basis of analyses that demonstrate a similar genetic signature (Wilson et al. 2000; Chambers et al. 2012; Rutledge et al. 2012), some researchers have also suggested that the Eastern Wolf may be conspecific[10] with the Red Wolf (*Canis rufus*), an endangered species that is present in the southeastern United States (Wilson et al. 2000; Grewal et al. 2004; Kyle et al. 2006). It remains possible that the Eastern Wolf and Red Wolf populations have the same historical origin (Grewal et al. 2004; Kyle et al. 2006, 2008; Rutledge et al. 2012; COSEWIC 2015). However, due to introgression[11] of Coyote, Domestic Dog (*Canis lupus familiaris*) or Grey Wolf genes during the Red Wolf captive breeding program (Hailer and Leonard 2008; vonHoldt et al. 2011; Wilson et al. 2012), it is likely that the Red Wolf, as now found in the southeastern United States, no longer meets the criteria used to define the Eastern Wolf (see section 3.3 *Species Population and Distribution*; COSEWIC 2015).

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[7] In this document, as in the COSEWIC status report (2015), coyote (*Canis latrans*) means the small canid native to areas west of the Mississipi River that moved northward and eastward at the time of European settlement of North America. The Coyote is believed to have arrived in Ontario around the early 1900s, in southeastern Ontario in 1919, and in Quebec (Outaouais region) in 1944 (Nowak 1979).
[8] This theory corresponds to the “2-species hypothesis” (Grey Wolf and Coyote), whose hybridization produced a variety of hybrids, including the Eastern Wolf (COSEWIC 2015, Appendix 1).
[9] This theory corresponds to the “3-species hypothesis” (Grey Wolf, Eastern Wolf and Coyote) (COSEWIC 2015, Appendix 1).
[10] Belonging to the same species.
[11] Introduction of genes of one species in the gene pool of another species, occurring when matings between the two produce fertile hybrids.

3.2 Species Description

The common names of Eastern Wolf include, but are not limited to, the Eastern Grey Wolf, Eastern Timber Wolf, Canadian Wolf and Algonquin Wolf. The body size and skull characteristics of Eastern Wolves are generally considered to be intermediate between those of the Grey Wolf and the Coyote (Kolenosky and Standfield 1975; Schmitz and Kolenosky 1985; Sears et al. 2003; Theberge and Theberge 2004; Rutledge et al. 2010c, 2010d; Benson et al. 2012). In Algonquin Provincial Park, the average weight of Eastern Wolf adult males was 30.3 kg (standard error of 0.6 kg, n=48) and the average weight of adult females was 23.9 kg (standard error of 0.6 kg, n=40; Theberge and Theberge 2004). In Quebec, Hénault and Jolicoeur (2003) report that the average weight of male wolves, including Eastern Wolves, Grey Wolves and most likely hybrids, ranged from 24.7 kg (Papineau-Labelle Wildlife Reserve) to 44.5 kg (La Mauricie National Park and surrounding area, including the Saint-Maurice Wildlife Reserve, the Mastigouche Wildlife Reserve and the Chapeau-de-Paille controlled harvesting zone [ZEC]), and the average weight of females ranged from 21.7 kg (on the outskirts of the La Vérendrye Wildlife Reserve) to 28.2 kg (La Mauricie National Park and surrounding area). The coat colour of the Eastern Wolf is quite variable, but is usually described as tawny, with more reddish-brown and brown highlights than the Grey Wolf and the Great Lakes–Boreal Wolf (Young and Goldman 1944; Kolenosky and Standfield 1975). Eastern Wolves observed in the wild are also sometimes confused with Coyotes, which are similar in appearance, although Coyotes are generally considered to have a narrower muzzle, larger ears and proportionally smaller feet relative to their body size (OMNR 2005a). Eastern Coyotes can be difficult to differentiate morphologically from the Eastern Wolf, since their appearance is intermediate and may resemble both the Coyote and the Eastern Wolf (Benson et al. 2012). Given the significant morphological variability in the Eastern Wolf and its similarities with other canids (Rutledge et al. 2010c), it is often very difficult to identify the Eastern Wolf without an assignment test using genetic markers (Rutledge 2010a; COSEWIC 2015).

3.3 Species Population and Distribution

The analysis of the current populations and distribution of the Eastern Wolf is complicated by the confusion caused by its ability to hybridize with other species of the genus *Canis* (see section 3.1 *Species History*). Given the varying degrees of hybridization of Eastern Wolves with other canids, the recognition of individuals as members of the species *Canis* sp. cf. *lycaon* is based, according to the COSEWIC status report (2015), on the probability of genetic assignment to this group ($Q \geq 0.8$; Rutledge et al. 2010c; COSEWIC 2015). This threshold establishes that individuals for which the probability of genetic assignment is less than 0.8 are considered canid hybrids.[12]

The Eastern Wolf exploits a relatively narrow ecological niche, which differs from that of the Grey Wolf and the Eastern Coyote (COSEWIC 2015). Unlike the Eastern Coyote, it is found in minimally human-impacted regions and needs larger prey (e.g., White-tailed Deer [*Odocoileus virginianus*], Beaver [*Castor canadensis*]) to meet its energy requirements (Rutledge et al. 2010c). In addition, the Eastern Wolf occurs more often in mixedwood forest regions, while the Grey Wolf is generally found in boreal forests, where there is a higher density of Moose (COSEWIC 2015). See section 3.4 *Needs of the Eastern Wolf* for further details on the ecological niche of the Eastern Wolf.

Although its historical range likely covered part of the United States (Wilson et al. 2000; Kyle et al. 2006; Rutledge et al. 2010d; COSEWIC 2015), the known range of the Eastern Wolf, as described here, is currently limited to Canada, namely Ontario and Quebec (COSEWIC 2015). Indeed, assuming that the Eastern Wolf and the Red Wolf are conspecific, it is believed that the historical range of the Eastern Wolf included the entire temperate forest region of the eastern United States and southeastern Canada (Wilson et al. 2000; Rutledge et al. 2010d). However, it is also possible that the species' historical range was more limited and further to the north and did not include the range of the Red Wolf (Nowak 1995). The historical Canadian range is estimated at approximately 100,000 to 500,000 km^2 (COSEWIC 2015). In the early 19th century, logging, agricultural practices and other human activities resulted in large-scale landscape changes as well as an intensification of hunting and trapping of top-level predators.[13] It is approximately at this time that the range of Eastern Wolves and their main prey is believed to have shifted to include areas further north, i.e., in Ontario and

[12] Eastern Wolf in Quebec was identified by two similar methods. One of the methods is the same as that used in Algonquin Provincial Park (Rutledge and White 2013, 2014), whereas the analyses by Stronen et al. (2012), Rogic et al. (2014), Hénault (unpub. data) and Tessier (unpub. data) used a small proportion of samples from the Algonquin Park area and, according to COSEWIC (2015), included as Eastern Wolves samples that would likely have been identified as admixed animals under the Rutledge and White method (2013; 2014). In accordance with the method used by COSEWIC (2015), the extent of occurrence of the Eastern Wolf is defined in this report using the results of Rutledge and White (2013; 2014) only, but the results obtained by the two methods are represented in Figure 1.

[13] Also known as apex predators or super predators, these organisms generally have no predators apart from other super predators, reside at the top of the food chain and are believed to have the capacity to self-regulate their population density (Wallach et al. 2015). These organisms often play an essential role in regulating their ecosystem (Estes et al. 2011; Ripple et al. 2014).

Quebec (Hall and Kelson 1959; Kyle et al. 2006; Wilson et al. 2009). The Eastern Coyote, a species tolerant to human disturbances, likely replaced the Eastern Wolf in certain parts of southern Canada over the last century, including southern Ontario and southern Quebec.

In the United States, data on distribution are incomplete or have not been examined for this taxon (NatureServe 2017). It is possible that the species' range may extend from eastern Minnesota to Wisconsin and Michigan, but the wolves containing Eastern Wolf genetic material found in these regions appear to be mainly Great Lakes–Boreal Wolves (Wheeldon and White 2009; Mech 2010a; Thiel and Wydeven 2011).

The extent of occurrence[14] (Figure 1) is estimated at 126,573 km², while the area of occupancy[15] is estimated at 31,821 km² (COSEWIC 2015; Tessier, unpub. data[16]). In Canada, the current distribution of the Eastern Wolf is thought to be restricted to the mixed forest zone of central Ontario and southwestern Quebec, i.e., the Great Lakes and St. Lawrence Forest Region (COSEWIC 2015). In Ontario, the Eastern Wolf is found in Algonquin Provincial Park and the surrounding townships, as well as in Killarney Provincial Park and near French River Provincial Park, in Queen Elizabeth II Wildlands Provincial Park and in Kawartha Highlands Provincial Park (Benson et al. 2012; COSEWIC 2015; Rutledge et al. 2016.). Its distribution in Quebec includes the Papineau-Labelle Wildlife Reserve and surrounding area, Maganasipi ZEC, the Mont-Tremblant National Park and Rouge-Matawin Wildlife Reserve area, the Laurentides Wildlife Reserve ad La Mauricie National Park and surrounding area (including in particular the Saint-Maurice Wildlife Reserve and the Mastigouche Wildlife Reserve; Potvin 1987; Villemure and Festa-Bianchet 2002; Villemure 2003; Villemure and Masse 2004; Rogic et al. 2014; Tessier, unpub. data). Outside the current extent of occurrence, research including samples of wolves from Duck Mountain Provincial Park and Riding Mountain National Park in Manitoba have established the presence of Eastern Wolf genetic material in that province (Wilson et al. 2000; Stronen et al. 2010; Rutledge et al. 2010b). Eastern Wolf genetic material has also been detected in wolves living as far west as Manitoba and Saskatchewan (Stronen et al. 2010; Stronen, pers. comm. 2011). However, it appears that most of the wolves in Manitoba that have *Canis* sp. cf. *lycaon* genetic material are Great Lakes–Boreal Wolves (Wheeldon 2009). Lastly, until recently, no microsatellite profiles characteristic of the Eastern Wolf had been found in canids in the Maritimes (Way et al. 2010; COSEWIC 2015), but Eastern Wolf genetic material has since been detected in an individual (*C. lupus* x *C.* sp. cf. *lycaon*) captured in New Brunswick (McAlpine et al. 2015).

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[14] The area included in a convex polygon encompassing the geographic distribution of all known populations of a species.

[15] The index calculates the area within the "extent of occurrence" that is potentially occupied by the species. This index is based on the size of the sites (i.e., protected areas) where the Eastern Wolf has been recorded. See the COSEWIC status report (2015) for more details.

[16] The difference between the area presented here and the area shown in Table 2 of the COSEWIC status report (COSEWIC 2015) corresponds to the areas of the Mastigouche Wildlife Reserve (1,565 km^2) and the Saint-Maurice Wildlife Reserve (784 km^2), adjacent to La Mauricie National Park, where Eastern Wolves have been identified by genetic analysis (N. Tessier, unpub. data).

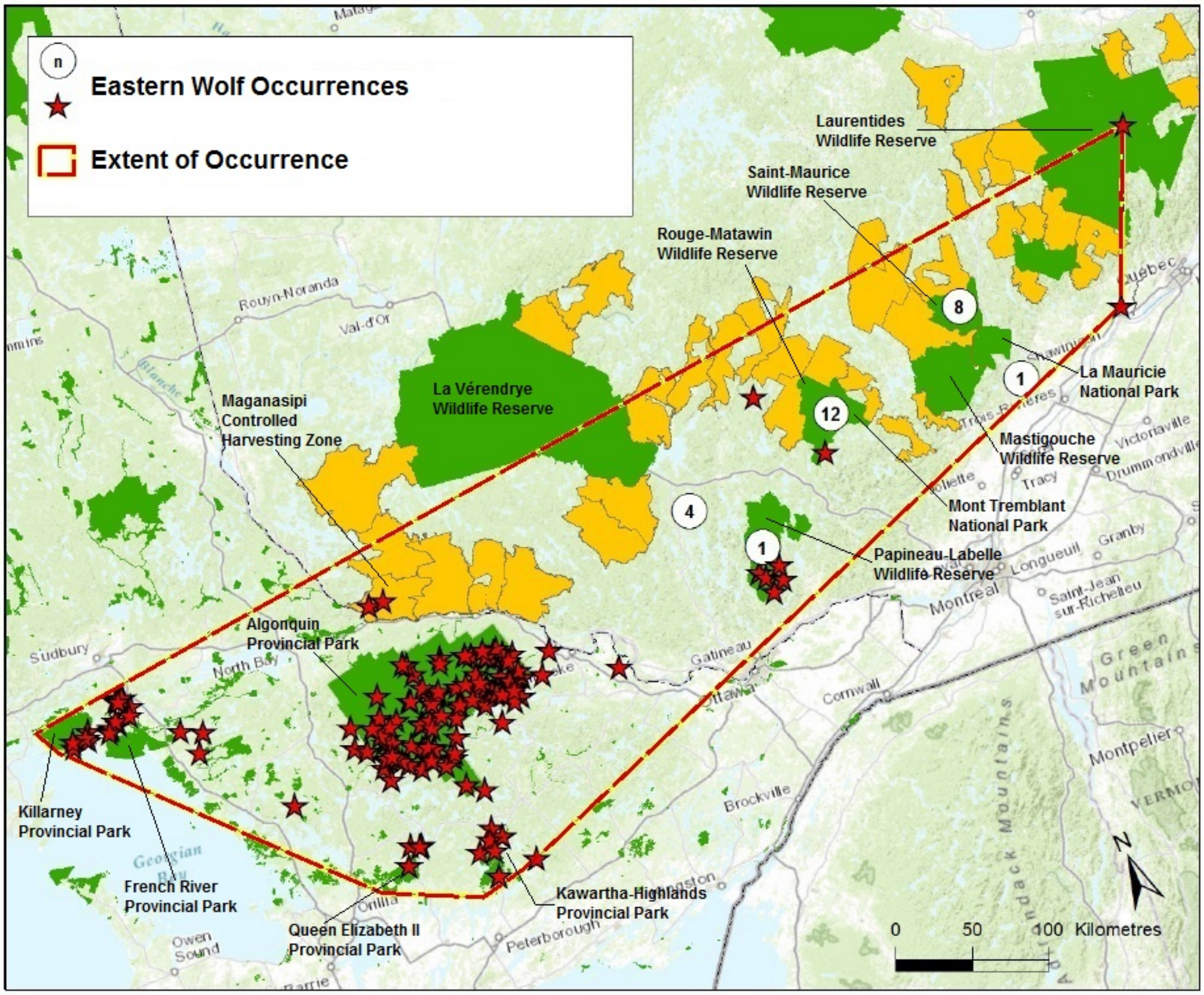

Figure 1. Extent of occurrence of the Eastern Wolf, represented by the area within the polygon delimited by the dotted red line, including most of the known locations of the species, according to the COSEWIC status report (adapted from COSEWIC 2015). The locations shown were derived from various sources, some of which use a common methodology (red stars: Rutledge 2010a; Rutledge et al. 2010b, 2010c; Rutledge and White 2013, 2014) or other methods (circles: Rogic et al. 2014; Hénault, unpub. data; Tessier, unpub. data). The number within the circles indicates the number of individuals identified, and the position of the circle indicates the approximate area (and not necessarily the exact location) where the individuals were found. The areas shown in dark green are national parks, provincial parks and wildlife reserves, while the areas shown in yellow are controlled harvesting zones (ZECs). The existing Eastern Wolf locations shown here are not exhaustive. For example, additional locations within the extent of occurrence are presented in Rutledge et al. (2016) in the area of Killarney Provincial Park, French River Provincial Park, Queen Elizabeth II Wildlands Provincial Park, Kawartha Highlands Provincial Park and Algonquin Provincial Park.

To estimate the minimum number of Eastern Wolves within the extent of occurrence, a method similar to that used in the COSEWIC status report (2015) was employed, whereby only protected areas[17] where the species has been detected were considered as sites where the Eastern Wolf may occur, and the abundance of wolves was assessed using the estimated density of wolves,[18] to which a correction was applied based on the approximate proportion of wolves that are Eastern Wolves.[19]. The proportion of mature individuals (i.e., two years and older) within the population was estimated at 46% (Patterson, unpub. data cited in COSEWIC 2015). In order to estimate the maximum number of Eastern Wolves within the extent of occurrence, the total area of the extent of occurrence (126,573 km²) was multiplied by the estimated density of wolves in Algonquin Provincial Park (3.0 individuals/100 km^2 x 69% = 2.07 individuals/100 km^2).

It was thus estimated that the number of Eastern Wolves within the extent of occurrence was between 450 and 2,620 individuals, 205 to 1,203 of that number being mature individuals.[20] The estimation of the upper value of the range was based on the assumption that Eastern Wolf density throughout the extent of occurrence is equivalent to that observed in Algonquin Provincial Park, which is unlikely. Given the threats to the Eastern Wolf outside protected areas, the number of mature individuals is probably closer to the lower value of the range and is very likely below 1000 (COSEWIC 2015).

[17] In accordance with the description of the various protected areas categories of the International Union for Conservation of Nature (IUCN 2016), areas considered “protected” include parks, wildlife reserves, and locations where hunting and trapping of wolves and Eastern coyotes are prohibited. In estimating the minimum abundance, only protected areas are taken into account, given that few records of Eastern Wolves occur outside protected areas and that these records typically are of single animals (COSEWIC 2015).

[18] The estimated densities of wolves in Algonquin Provincial Park (3.0 individuals/100 km^2; Rutledge et al. 2010e) were used for the sites located in Ontario, and the respective estimated densities in the Papineau-Labelle Wildlife Reserve (2.6 individuals/100 km^2; Potvin 1986, 1987), in the Rouge-Matawin Wildlife Reserve and Mont-Tremblant National Park (1.6 individuals/100 km^2; Hénault and Jolicoeur 2003), in La Mauricie National Park, in the Saint-Maurice Wildlife Reserve and the Mastigouche Wildlife Reserve (1.3 individuals/100 km^2; Villemure 2003), and in the Laurentides Wildlife Reserve (0.44 individuals/100 km^2; Jolicoeur 1998) were used for the sites in Quebec. This density was multiplied by the respective area of the sites, the largest of which include the Laurentides Wildlife Reserve (7,861 km^2), Algonquin Provincial Park (7,571 km^2) and the surrounding townships (6,340 km^2), the Rouge-Matawin Wildlife Reserve and Mont-Tremblant National Park (3,165 km^2), the La Mauricie National Park, Saint-Maurice Wildlife Reserve and Mastigouche Wildlife Reserve region (2,885 km^2), and the Papineau-Labelle Wildlife Reserve (1,628 km^2).

[19] A correction was applied to the values obtained by multiplying them by an estimate of the proportion of wolves assigned to the Eastern Wolf species (69%; data from Rutledge et al. 2010c, in Algonquin Provincial Park; COSEWIC 2015).

[20] The estimates mentioned in the COSEWIC status report (COSEWIC 2015) are from 516 to 2,620 individuals, of which 236 to 1,203 are mature individuals. The differences between the estimates of numbers of individuals provided here and those indicated in Table 2 of the COSEWIC status report (COSEWIC 2015) are attributable in part to the fact that more specific densities are used here for the various sectors of Quebec (as previously mentioned), and in part to the inclusion of the areas of the Mastigouche Wildlife Reserve and of the Saint-Maurice Wildlife Reserve, adjacent to La Mauricie National Park, where Eastern Wolves have been identified by genetic analysis (N. Tessier, unpub. data).

The effective population size[21] of the Eastern Wolf population in and around Algonquin Provincial Park has been estimated at 24 to 122 (depending on the approach used), with a harmonic mean of 46 (Rutledge et al. 2016).

3.4 Needs of the Eastern Wolf

Wolves[22] live and hunt in social groups called "packs." Although packs of 12 to 14 wolves have occasionally been reported (Theberge and Theberge 1998), a pack usually consists of 2 to 10 wolves (Pimlott et al. 1969; Potvin 1987; Villemure 2003; Loveless 2010).

Wolves use scent marking (i.e., the smell of feces, urine, anal glands) to demarcate territory and minimize encounters with neighbouring packs, although they do defend their territory if necessary.

Eastern Wolves use various types of habitats, but are generally found in extensive forested areas (COSEWIC 2015). Certain wolf habitat preferences may be explained by an association with prey (Mladenoff et al. 1997; McLoughlin et al. 2004; Desy 2007; Loveless 2010), but wolves may select their habitat with a view to facilitating their movements, increasing their hunting success, and avoiding intraspecific conflicts[23] as well as areas associated with human presence or busy roads. Estimated average territory sizes are 199 km^2 (85 to 324 km^2) in the Papineau-Labelle Wildlife Reserve in Quebec (Potvin 1987), 645 km^2 (623 to 659 km^2) in La Mauricie National Park and surrounding area in Quebec (Villemure 2003; data including hybrids), and 190 km^2 (49 to 330 km^2) in Algonquin Provincial Park in Ontario (Loveless 2010).

Breeding females in Eastern Wolf packs produce litters of up to seven pups annually if resources permit, with an average of 4.6 (Mills et al. 2008). In the spring, the females give birth in dens, where the pups will also be raised (Jolicoeur et al. 1998; Norris et al. 2002; Trapp 2004). Dens can include underground tunnels, generally excavated in well-drained cohesive soils (e.g., sandy soils, that may include silt or gravel), as well as crevasses, rock caves, spaces under tree roots, hollow logs or stumps, or abandoned beaver lodges (Joslin 1967; Pimlott 1967; Jolicoeur et al. 1998; Norris et al. 2002; Patterson, pers. comm. 2009; Benson et al. 2015). Dens are often selected near wetlands or water bodies, likely because of the importance of water to lactating females, which seek to avoid leaving their pups unattended (Mills et al. 2008; Benson et al. 2015). The pack uses one or more dens during the first 4 to 15 weeks of the pups' life (Jolicoeur et al. 1998; Benson et al. 2015). In Algonquin Provincial Park, Eastern

[21] The effective population size corresponds to the theoretic number of individuals in an ideal population (Fisher 1930; Wright 1931), for which there is believed to be a degree of genetic drift equivalent to that of the actual population. This value is used to estimate the risk of genetic decline in a population. The effective population size required for a population to retain its evolutionary potential sets a lower limit to viable population size for wildlife (Soulé 1987 cited in Franklin and Frankham 1998).
[22] Since very little information specific to Eastern Wolves exists at present and since the data for certain areas may relate to both Eastern Wolves and hybrids, some of the information on "wolves" is given merely as an example, except where the "Eastern Wolf" is specified.
[23] Occurring between members of the same species.

Wolves commonly establish their den sites in conifer forests (Benson et al. 2015), including pine (*Pinus* spp.) stands (Norris et al. 2002), possibly owing to the sandy soils associated with these stands (Mech 1970; Ballard and Dau 1983). However, the study by Benson et al. (2015) shows that Eastern Wolves exhibited only marginal selection for conifer stands (33% of dens) in Algonquin Provincial Park. A description of the dens used by wolf packs in the Laurentides Wildlife Reserve and surrounding area also indicates that dens may be surrounded by several types of stands, including black spruce stands, balsam fir stands and scrubland (Jolicoeur et al. 1998). The dens are sometimes reused from year to year by the pack (Jolicoeur et al. 1998; Benson et al. 2015), but the rate of reuse in Algonquin Provincial Park is low (Benson et al. 2015), where the availability of dens is not believed to be a limiting factor (Norris et al. 2002; Argue et al. 2008).

During the rest of the summer, the pups spend most of their time in a series of rendezvous sites, which become the focal point of pack activities (Joslin 1967; Argue et al. 2008). Rendezvous sites are usually located near a permanent water source, often on the edges of lakes, ponds, streams or peatlands, and may be found in various open and forested habitats (Joslin 1967; Jolicoeur et al. 1998). In Algonquin Provincial Park, primarily conifer stands are selected (Benson et al. 2015). The location of rendezvous sites appears to depend on various factors, including kill sites and type of prey (Theberge and Theberge 2004; Benson et al. 2015). Between May and August, wolves that are not in the den or at a rendezvous site appear to be generally found near a permanent water source, such as a peatland, pond, lake or stream (on average at 91 m ± 27 m from the water), possibly related to predation of beavers or ungulates coming to drink there (Theberge and Theberge 2004).

The Eastern Wolf feeds on White-tailed Deer, Moose (*Alces alces*) and Beaver, as well as a wide variety of smaller animals (Forbes and Theberge 1996b; Potvin et al. 1988; Villemure 2003; OMNR 2005a; Kittle et al. 2007; Loveless 2010). Like other canids, the Eastern Wolf can cache food for later use. Moldowan and Kitching (in press) observed an Eastern Wolf (or possibly a hybrid) caching part of a White-tailed Deer calf carcass in a sphagnum bog in Algonquin Provincial Park, whose microhabitat could help preserve the hidden food.

According to COSEWIC (2015), yearlings and adults have a life expectancy of 6.2 years and pups have a life expectancy of 0.7 to 3.5 years.

3.4.1 Limiting Factors

Eastern Wolf populations are limited by prey availability: wolf densities are generally higher in areas with a higher density of prey (Messier and Crête 1985; Fuller et al. 2003). For example, the decline in the abundance of wolves in Algonquin Provincial Park between the early 1960s and the 1990s was attributed in part to a change in prey populations, specifically a lower number of deer in the park during the winter and summer months and a decrease in the number of beavers (Algonquin Wolf Advisory Group 2000; Quinn 2005). Wolves living in areas with a low prey density also have lower survival and reproduction rates (Messier 1985, 1987). Although wolves are considered generalist predators, whose main types of prey are determined by availability, accessibility and profitability[24] (Peterson and Ciucci 2003), the Eastern Wolf is generally found less frequently in areas where the White-tailed Deer is absent. Although predator-prey dynamics are important, they are not necessarily sufficient to explain the variations in Eastern Wolf abundance, particularly in the presence of human-caused mortality (Theberge and Theberge 2004).

Furthermore, Benson and Patterson (2013) have shown that packs of large canid species (Eastern Wolves, Gray Wolves and Eastern Coyotes) are territorial and that this reduces the possibility of Eastern Wolf population expansion outside of already occupied sites. It is therefore not very likely, for example, that dispersing Eastern Wolves will become established in a territory already occupied by a pack of Eastern Coyotes. They are more likely to join other canid packs and possibly hybridize with Eastern Coyotes (see *Introduced genetic material (IUCN Threat 8.3) – hybridization of the Eastern Wolf with the Eastern Coyote*).

Hybridization may in some cases be considered a natural evolutionary process, but it may also be exacerbated by human activity (Allendorf *et al*. 2001). For this reason, hybridization of the Eastern Wolf with the Grey Wolf is considered a limiting factor rather than a threat, since the two species were already evolving in sympatry[25] prior to European settlement of North America (Nowak 1995) and their hybridization does not appear to be intensified by human activity. Therefore, a natural hybridization zone exists between the areas occupied by the Eastern Wolf and those occupied by the Grey Wolf, where Great Lakes–Boreal Wolves occur, whose stability is ensured by the fact that the Grey Wolf and the Eastern Wolf have different habitat and prey needs (Kolenosky and Standfield 1975; Geffen et al. 2004; Wheeldon 2009). In a stable system such as that, hybridization can even benefit Eastern Wolves by increasing genetic diversity and thus the species' ability to respond to environmental change (such as climate change) (Hamilton and Miller 2015; Jackiw et al. 2015). Hybridization with the Eastern Coyote is considered a threat because it is exacerbated by human activity (see *Introduced genetic material (IUCN Threat 8.3) – hybridization of the Eastern Wolf with the Coyote*).

Competition with Grey Wolves or Great Lakes–Boreal Wolves is likely another limiting factor for Eastern Wolf populations. However, there is little documented evidence of this.

Finally, it is also possible that intraspecific aggression is more frequent when Eastern Wolf densities increase (Rutledge et al. 2010e), and this may be a limiting factor intrinsically related to population density, as has been demonstrated for the Grey Wolf in Yellowstone Park (Cubaynes et al. 2014).

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[24] Profitability corresponds to the ratio between the energy obtained and the time required to catch a prey.
[25] Whose area of occupancy overlaps.

4. Threats

The threats to the Eastern Wolf may vary regionally and locally throughout its range in Canada. The information presented in Table 1 is an overall assessment of the threats to the species across Canada. Where information is known on the significance of a given threat at the regional or local scale, additional information is provided in the threats description section.

4.1 Threat Assessment

The threat assessment for the Eastern Wolf is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system (Table 1). Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem; in this case, the Eastern Wolf) in the area of interest (global, national, or subnational; in this case Canada). Limiting factors are not considered during this threat assessment process. For purposes of threat assessment, only present and future threats are considered. Historical threats, indirect or cumulative effects of the threats, or any other relevant information that would help understand the nature of the threats are presented in section 4.2 *Description of Threats*.

The predominant threats to the Eastern Wolf are hunting, trapping and poaching, as well as roads and hybridization with the Eastern Coyote.

Table 1. Threat Classification Table for the Eastern Wolf

Threat #	Threat Description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
1	Residential and commercial development	Low	Small	Extreme	High	Indirect threats (e.g., increased access and hunting and trapping pressure and increased hybridization) are dealt with under these other threats. It was assumed that new urban developments are causing the most severe impact; however, Eastern Wolves can use cottage or housing areas that remain relatively undeveloped.
1.1	Housing and urban areas	Low	Small	Extreme	High	–
1.2	Commercial and industrial areas	Negligible	Negligible	Extreme	High	–
1.3	Tourism and recreation areas	Low	Small	Serious-Moderate	High	–
2	Agriculture and aquaculture	Negligible	Negligible	Serious-Slight	Moderate	The scope of the threat posed by agriculture was assessed as negligible considering that a large proportion of the current area of occupancy of the Eastern Wolf is located in protected areas where this type of activity is absent or strictly regulated.
2.1	Annual and perennial non-timber crops	Negligible	Negligible	Serious-Slight	Moderate	Given the uncertainty concerning use by the Eastern Wolf of habitat outside protected areas, severity was defined by means of a range of values (Serious-Slight).
2.2	Wood and pulp plantations	Negligible	Negligible	Negligible	High	It seems that plantations do not pose a threat in Ontario, but will constitute a threat in Quebec.
2.3	Livestock farming and ranching	Negligible	Negligible	Unknown	High	Livestock farming may increase in Ontario. There is much uncertainty in this regard in Quebec.
3	Energy production and mining	Negligible	Negligible	Extreme	High	The scope of the threat posed by drilling and mining and quarrying was assessed as negligible considering that a large proportion of the current area of occupancy of the Eastern Wolf is located in protected areas where these activities are not permitted, and moreover it appears that few projects of this type will take place in the near future.
3.1	Oil and gas drilling	Negligible	Negligible	Negligible	Negligible	–
3.2	Mining and quarrying	Negligible	Negligible	Extreme	High	The scope may be greater in Ontario, near the lower limit of “small.”

Threat #	Threat Description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
4	Transportation and service corridors	Medium-Low	Pervasive	Moderate-Slight	High	–
4.1	Roads and railroads	Medium-Low	Pervasive	Moderate-Slight	High	In the assessment of this threat, mortality associated with roads was taken into account, as well as habitat loss. Indirect threats (e.g., increased access for hunting and trapping and increased hybridization) are dealt with under these other threats. The scope of the threat posed by roads was assessed as pervasive, since all types of roads were considered (including logging roads). With regard to severity, “moderate-slight” was used to denote uncertainty. Mortalities have been signaled in Quebec and in Ontario.
4.2	Utility and service lines	Negligible	Small	Negligible	High	The assessment of the scope of this threat (including for example power transmission lines and pipelines) includes only the new structures that might be built and associated rights-of-way. The scope is considered to be lower than 1% in Ontario and nearly 1% in Quebec.
5	Biological resource use	High-Medium	Large	Serious-Moderate	High	–
5.1	Hunting and collecting terrestrial animals	High-Medium	Large	Serious-Moderate	High	In the assessment of this threat, trapping, hunting and poaching were taken into account, as well as incidental take. The scope “large” rather than “pervasive” is explained by the fact that a large proportion of the packs have territories located largely in protected areas where hunting and trapping are prohibited. For severity, the range “serious-moderate” was used to denote uncertainty. Ontario: when wolves leave protected areas, the threats they face are much greater. Québec: severity depends on the different group and the proportion of animals that are outside protected areas; may not be serious in some locations.

Threat #	Threat Description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
5.3	Logging and wood harvesting	Not a threat	Large	Neutral or potentially beneficial	High	COSEWIC has assessed logging and wood harvesting and determined that it was not a threat. An impact could occur in the event of the cutting of stands surrounding dens or rendezvous sites, but the cutting of other stands could be of some benefit associated with an increase in ungulate prey density.
6	Human intrusions and disturbances	Negligible	Pervasive	Negligible	High	–
6.1	Recreational activities	Negligible	Pervasive	Negligible	High	The recreational activities considered include, but are not limited to: snowmobiling, use of ATVs, boating, hiking and ecotourism activities associated with wolves.
7	Natural system modifications	Negligible	Restricted-Small	Negligible	High	–
7.1	Fire and fire suppression	Negligible	Restricted-Small	Negligible	High	Forest fires are a natural process that can, however, restrict the habitat available for the Eastern Wolf.
7.2	Dams and water management/use	Negligible	Negligible	Extreme	High	The implementation of new major dam construction projects in the area of occupancy of the Eastern Wolf is not anticipated. The scope was therefore considered negligible. The severity of the threat has been assessed as “extreme” given that large areas could become unsuitable for the Eastern Wolf in the event of flooding of habitat due to possible future major dam construction.
8	Invasive and other problematic species and genes	Medium	Pervasive	Moderate	High	–
8.1	Invasive non-native/alien species	Unknown	Pervasive	Unknown	High	This threat deals with the diseases, parasites and threats associated with domestic animals (mainly the domestic dog); the hybridization of the Eastern Wolf with the Eastern Coyote is dealt with in point *8.3 – Introduced genetic material*. The severity of this threat is unknown, in both Quebec and Ontario. The scope is pervasive in Ontario and unknown in Quebec.

Threat #	Threat Description	Impact[a]	Scope[b]	Severity[c]	Timing[d]	Detailed threats
8.3	Introduced genetic material	Medium	Pervasive	Moderate	High	In the assessment of this threat, the hybridization of the Eastern Wolf with the Eastern Coyote was taken into account. The assessment of the threat takes into consideration the fact that a large proportion of the packs have territories located largely in protected areas where hunting and trapping are prohibited and, consequently, where the introgression of Eastern Coyote genes is more limited (see details in the description of the threat in section 4.2). Severity may be more serious in the area of Algonquin Provincial Park, but “moderate” when all populations are considered.
9	Pollution	Negligible	Small	Negligible	High	–
9.4	Garbage and solid waste	Negligible	Small	Negligible	High	The severity of the threat associated with waste collection and landfill sites was considered negligible given the positive and negative effects on the species. As a matter of fact, landfill sites can encourage movements out of the territory, thereby increasing the risk of human-related mortality or interpack aggression (Patterson, pers. comm. 2017), but can also be a food source.

[a] **Impact –** The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not Calculated: impact not calculated as threat is outside the assessment timeframe (e.g., timing is insignificant/negligible or low as threat is only considered to be in the past); Negligible: when scope or severity is negligible; Not a Threat: when severity is scored as neutral or potential benefit.

[b] **Scope** – Scope – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species’ population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%; Negligible < 1%).

[c] **Severity –** Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or 3-generation timeframe. Usually measured as the degree of reduction of the species’ population. (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).

[d] **Timing –** High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

4.2 Description of Threats

The threats to the Eastern Wolf are described below in descending order of threat impact by category (main threats, threats of low or negligible impact, and potential threats). Under each category, the numbering of the threats corresponds to the numbering in Table 1, and they are therefore not necessarily presented in order of relative impact.

4.2.1 Main threats

<u>Roads and railroads (IUCN Threat 4.1)</u>

Transportation corridors in themselves do not necessarily negatively impact wolves, particularly narrow logging roads or roads with a low traffic volume, especially those at a greater distance from primary roads (Popp and Donovan 2016). In fact, wolves can use certain types of secondary and tertiary roads to facilitate their movements and improve their predation success (Noss 1990; Whittington et al. 2011; Lesmerises et al. 2012). Studies have shown that wolves can persist in areas where habitat is fragmented, provided they are not subject to harvesting and provided these fragmented habitats maintain the characteristics necessary to the survival of wolves in this area (Mech 1989; Fuller et al. 1992; Berg and Benson 1999; Merrill 2000; Fritts et al. 2003; Holloway 2009). The increased access that roads provide to humans (including hunters and trappers; see *Hunting and collecting terrestrial animals (IUCN Threat 5.1) – hunting, trapping and poaching* section) is an indicator of the increase in the hunting and trapping harvest (Benson *et al*. 2012, 2014). Furthermore, in some areas collisions with vehicles are a significant source of Eastern Wolf mortality, including in and around the Papineau-Labelle Wildlife Reserve (Potvin 1987) and Algonquin Provincial Park (Friends of Algonquin Park 2015). Roads can also cause a loss of suitable habitat (e.g., a reduction in habitats containing sufficient prey) and give Eastern Coyotes better access to the prey species that live on the forest edge. Higher road density also increases the probability of hybridization between Eastern Wolves and Eastern Coyotes (Benson et al. 2012).

It has been suggested that maintenance of road density to less than 0.3 to 0.7 km of roads per km^2 was necessary to support wolves, with a low proportion of these roads being highways (roughly below 0.02 km/km^2) (Wydeven et al. 1998; Rateaud et al. 2001). Areas in southern Ontario and southern Quebec where the road network is very dense can significantly impede natural expansion of the Eastern Wolf in its historical range (COSEWIC 2015). The road density in southern Ontario is generally greater than 0.6 km/km^2 (Buss and deAlmeida 1997) and has been increasing over the past several decades (COSEWIC 2015).

Hunting and collecting terrestrial animals (IUCN Threat 5.1) – hunting, trapping and poaching

Wolves are regulated species of furbearing mammals in both Ontario (*Fish and Wildlife Conservation Act* [S.O. 1997, c. 41]) and Quebec (*Act Respecting the Conservation and Development of Wildlife* [C.Q.L.R., c. C-61.1]).

In some regions of Canada, Eastern Wolves are or have been hunted or trapped for both commercial (e.g., by licensed trappers) and recreational purposes. The trapping harvest largely exceeds the hunting harvest. For example, based on a mail-in survey conducted in southern Quebec, 97% of the reported harvest of wolves came from trapping (Jolicoeur *et al*. 2000). In addition to direct losses of individuals, harvesting activities can cause indirect impacts. Rutledge et al. (2010e) showed that a decrease in human-caused mortality, following the wolf harvesting ban in Algonquin Provincial Park and the surrounding townships, was accompanied by a restoration of the social structure of the packs and a decrease in the number of unrelated animals in the pack. Conversely, high harvesting rates are related to an increase in hybridization of the Eastern Wolf with the Coyote (Rutledge et al. 2011; Benson et al. 2014; see *Introduced genetic material [IUCN Threat 8.3] – hybridization of the Eastern Wolf with the Coyote*), which suggests that the presence of protected areas where harvesting is prohibited promotes the persistence of packs containing few or no hybrid individuals. The annual survival of Eastern Wolves is much higher in areas where hunting and trapping have been reduced or banned outright, compared to areas where hunting and trapping are permitted (Benson et al. 2014). Hunting could also have negative physiological effects (e.g., increased stress, which can contribute to the development of pathologies) in the remaining wolves in the pack, as illustrated in the Grey Wolf (Bryan et al. 2015; Molnar et al. 2015). In order to enhance the understanding of the effects of trapping on the Eastern Wolf population in Canada, additional information is provided in Appendix A for Quebec and Ontario.

Hunting and trapping of Eastern wolves and coyotes are prohibited in certain protected areas located within the area of occupancy, including the national parks of Canada (e.g., La Mauricie National Park), Quebec national parks (e.g., Mont-Tremblant National Park), Ontario provincial parks (e.g., Algonquin Provincial Park) and Crown game preserves in Ontario (e.g., Peterborough Crown Game Preserve). Hunting and trapping are also banned in certain other areas (e.g., since 2004 in the townships surrounding Algonquin Provincial Park and since 2016 in the townships around Kawartha Highlands, Queen Elizabeth II Wildlands and Killarney provincial parks [OMNRF 2016). Even though a large proportion of Eastern Wolf pack territories are located in protected areas or in areas where hunting and trapping are banned, there are a number of packs whose territories are located in whole or in part on lands where harvesting activities are permitted (e.g., wildlife reserves in Quebec or private lands near protected areas; see, for example, Potvin 1987; Theberge and Theberge 2004).

Eastern Wolves can also be incidentally harvested (legally or illegally) in association with big game hunting (e.g., during the hunting seasons for White-tailed Deer, Moose and Black Bear [*Ursus americanus*]) (Hénault and Jolicoeur 2003; OMNR 2005a;

Patterson, pers. comm. 2012 in COSEWIC 2015), or be killed out of hatred or fear of wolves (Hénault and Jolicoeur 2003; Theberge and Theberge 2004; Bath 2006). A certain quantity of Eastern Wolves have been harvested illegally in Ontario in locations where harvesting of coyotes and wolves is banned (Rutledge et al. 2010e). In addition, in areas where wolf hunting is or was prohibited, but where Eastern coyote hunting is allowed, Eastern Wolves were likely killed because they were confused with Eastern Coyotes (OMNR 2005a). Wolves have also been hunted and taken for sustenance and ceremonial purposes, as well as in the interest of public safety or in defence of property (e.g., livestock and domestic animals) (OMNR 2005a; *Endangered Species Act, 2007*).

<u>Introduced genetic material (IUCN Threat 8.3) – hybridization of the Eastern Wolf with the Eastern Coyote</u>

Coyotes quickly colonized eastern North America in the 20th century, including the historical area of occupancy of the Eastern Wolf, in part owing to human-induced changes to the landscape, such as the spread of agriculture (Kays et al. 2010). Coyotes reached southern Ontario in 1919 (Nowak 1979) and Quebec in 1944 (Naughton 2012). Intensive hybridization has been documented between Eastern Wolves and Coyotes, resulting in the establishment of a large population of Eastern Coyotes in northeastern North America (Way et al. 2010). It has been demonstrated that hybridization, accompanied by introgression, constitutes a significant threat to several species of the genus *Canis* on a global scale, including the Red Wolf (Wayne and Jenks 1991; Adams et al. 2003) and the Ethiopian Wolf (*Canis simensis*; Gottelli et al. 1994) as well as the Dingo (*Canis lupus dingo*; Elledge et al. 2008). This phenomenon appears to be even more frequent in the case of species that were historically allopatric[26] such as the Eastern Wolf and the Coyote (Stronen et al. 2012b). Hybridization is a significant threat to the long-term maintenance of the genetic identity of the Eastern Wolf, particularly in regions where its habitat is fragmented by human activities, which favours the presence of Eastern Coyotes, or when Eastern Wolf population densities are low owing to high mortality rates (Kays et al. 2010; COSEWIC 2015). Indeed, human-caused mortality of Eastern Wolves (see *Hunting and collecting terrestrial animals (IUCN Threat 5.1) – hunting, trapping and poaching*) is identified as one of the main causes of hybridization between Eastern Coyotes and Eastern Wolves in the area of Algonquin Provincial Park (Rutledge et al. 2011), in response to a lack of conspecific mates and disruption of Eastern Wolf pack structure (Rutledge et al. 2010c, 2010e). Gene introgression from Eastern Coyotes to Eastern Wolves appears, however, to be more limited in protected areas, such as Algonquin Provincial Park (Rutledge et al. 2011; Benson et al. 2012), because the environmental conditions and resource management regimes in such areas (e.g., regulations banning wolf harvesting in certain protected areas) help make conditions less conducive to hybridization (OMNR 2005a; Rutledge et al. 2010e).

[26] Whose area of occupancy does not overlap.

4.2.2 Threats of low or negligible impact

Residential and commercial development (IUCN Threat 1)

Residential and commercial development that results in changes at the landscape scale (e.g., residential and cottage construction, shopping centre construction, development of golf courses or ski trails) can reduce to varying degrees the area of suitable habitat available to the Eastern Wolf as well as to its main prey, while increasing the likelihood of encounters between wolves and humans (Mech 1996; Boitani 2003; Quinn 2005). Where there is some level of human-related wolf mortality, it is suggested that a population density of less than 4 to 8 humans per km² is required for the continued existence of the wolf population (Wydeven et al. 1998; Rateaud et al. 2001). Residential and commercial development can also cause declines in prey populations or changes in prey migration patterns, which can have a negative impact on the viability of a wolf population. It should be noted that residential and commercial development is typically accompanied by new road construction and can be associated with an increase in harvesting around the periphery of development. The effects of these threats are assessed in the *Hunting and collecting terrestrial animals* (*IUCN Threat 5.1*) – *hunting, trapping and poaching* and *Roads and railroads* (*IUCN Threat 4.1*) sections. Large protected areas such as Algonquin Provincial Park are rare in the range of the Eastern Wolf, and smaller areas, such as La Mauricie National Park, rarely support more than one wolf pack (Villemure 2003). Ongoing development continues to reduce suitable Eastern Wolf habitat and can increase the likelihood of hybridization with Eastern Coyotes, which more easily become established in disturbed areas (Lehman et al. 1991; Roy et al. 1994; see section *Introduced genetic material* (*IUCN Threat 8.3*) – *hybridization of the Eastern Wolf with the Eastern Coyote*). In addition to effects at the landscape scale, residential and commercial developments could cause adverse effects at the local scale, since Eastern Wolves, like Grey Wolves, likely avoid human infrastructure in the selection of breeding sites (dens, rendezvous sites) (Sazatornil et al. 2016).

Agriculture (IUCN Threat 2)

The conversion of suitable Eastern Wolf habitat to agricultural land results in a loss of forested habitat, which is an important component of the species' habitat. Rateaud et al. (2001) have shown that, in southern Quebec, when prey availability is not a limiting factor, wolves (Eastern Wolves, Grey Wolves and hybrids) live and persist in habitats that have an average forest cover of 82% or greater, but may be present irregularly when the cover is close to 60%. The threat caused by agriculture is also attributable to an increase in wolf mortality rates owing to the attitudes of some farmers towards wolves (Stronen et al. 2007; Mech 2010b; Way and Bruskotter 2012; COSEWIC 2015; this aspect is addressed in the section *Hunting and collecting terrestrial animals* (*IUCN Threat 5.1*) – *hunting, trapping and poaching*). The indirect threat associated with the increase in Eastern Coyote densities in agricultural areas is discussed in the section *Introduced genetic material* (*IUCN Threat 8.3*) – *hybridization of the Eastern Wolf with the Eastern Coyote.*

Recreational activities (IUCN Threat 6.1)

Recreational activities involving human intrusions into wolf habitat (e.g., wilderness camping) could have an impact on the Eastern Wolf packs affected. Wolves display avoidance behaviour to humans and tend to relocate newborn pups following a disturbance of their den or rendezvous site (Frame et al. 2007; Argue et al. 2008). This threat is not well documented. If we include all the types of recreational activities that take place in the extent of occurrence of the Eastern Wolf (e.g., snowmobiling, ATV use, boating, hiking), its scope is pervasive. However, the severity of the threat was considered negligible since the area of occupancy of the Eastern Wolf is mainly located in parks or wildlife reserves where these activities are well regulated.

4.2.3 Potential threats

Invasive/non-native alien species (IUCN Threat 8.1) – diseases, parasites and domestic animals

Although the severity of this threat is unknown (Brand et al. 1995), diseases and parasites can be a concern for small, threatened populations (Boitani 2003). Eastern Wolves are susceptible to a certain number of viral diseases, including rabies, canine distemper, canine parvovirus and canine hepatitis (Theberge et al. 1994; Theberge and Theberge 1998). They can also suffer significant mortality caused by mange, an ectoparasite[27] (Kreeger 2003), which could result in high energetic costs, as observed in the Grey Wolf (Cross et al. 2016). Eastern Wolves could also be exposed to various vector-borne diseases, such as anaplasmosis, ehrlichiosis, heartworm or Lyme's disease, as in the case of Grey Wolves in Wisconsin (Jara et al. 2016). Research on wolves in and around Algonquin Provincial Park suggests that diseases and parasites pose a low degree of threat to this population (Theberge et al. 1994; Theberge and Theberge 1998; Kreeger 2003). However, the occurrence of diseases and parasites among Eastern Wolves is believed to be more significant outside the large protected areas owing to increased contact with domestic dogs, Eastern Coyotes and other animals which can act as "reservoirs" for parasites and diseases.

Habitat shifting and alteration (IUCN Threat 11.1) – climate change

The severity of the threat that climate change poses to the Eastern Wolf has not yet been assessed. However, models predict a reduction in Moose densities in southern Ontario, including in the Algonquin Provincial Park area (Murray et al. 2006; Rempel 2011), as well as a possible increase in White-tailed Deer densities in Ontario and Quebec (Thompson et al. 1998; Murray et al. 2006). Although this increase in White-tailed Deer density would be beneficial to the Eastern Wolf, the anticipated reduction in snow cover will likely lead to reduced hunting success for the Eastern Wolf, which has an advantage over ungulates in heavy snow cover (DelGiudice et al. 2002; Crête and Larivière 2003). Climate change could also adversely affect the length of time that cached food can be preserved (Sutton et al. 2016).

[27] Parasite that lives on the outer surface of its host.

5. Management Objective

The management objective is to achieve and maintain a viable[28] Eastern Wolf population within the species' current range in Canada.

To meet this management objective, it is necessary, at a minimum, to maintain the Eastern Wolf densitty in the Algonquin Provincial Park area at its current level, which is estimated at approximately 2.1 individuals per 100 km^2 [29] (Rutledge et al. 2010c, 2010e; COSEWIC 2015). This area is important for the conservation of this species in Canada and the status of the Eastern Wolf is better documented in the park than in the rest of the species' Canadian range. Eastern Wolf distribution and abundance elsewhere in Ontario and Quebec has not been studied much. Until more detailed information is available as a baseline, a precautionary approach is important to maintain the species' presence in known occupied sites. Conservation of the species at these sites contributes significantly to the resilience[30] and redundancy[31] of the Canadian population. It also allows for maintenance of regional representativeness within the Canadian distribution. Lastly, connectivity between occupied sites and other regions of suitable habitat is required in order to facilitate dispersal of individuals and maintain genetic cohesion of the species in Canada. However, the dispersal routes used by the Eastern Wolf are not well documented and additional research is required to assess the species' connectivity needs.

An effective population size of at least 500 mature individuals is generally believed to be needed to sustain the genetic diversity required to ensure the viability of a population such as that of the Eastern Wolf in Canada (Franklin and Frankham 1998; Rutledge et al. 2016). The effective size of the Algonquin Provincial Park Eastern Wolf population is estimated at between 24 and 122 individuals (Rutledge et al. 2016; see section 3.3 *Species Population and Distribution*). Even considering the Eastern Wolves present outside the study area of Rutledge et al. (2016), including in Quebec, it is unlikely that the effective population size is currently at the 500-individual threshold. Moreover, Rutledge et al. (2016) estimate that a total population size of 2500 to 4545 Eastern Wolves would be needed to reach an effective population size of 500 individuals, which is much higher than the current estimate of 450-2620 individuals, the upper figure of which is considered unlikely (see section 3.3 *Species Population and Distribution*).

[28] A population that is sufficiently abundant and well adapted to its environment that it can persist in the long term (in the face of demographic, genetic and environmental stochasticity and natural disasters), without the need to manage it or to continually invest resources.
[29] The density figure of 3.0 individuals/100 km^2 from Rutledge et al. (2010e) was modified by multiplying it by an estimate of the proportion of these wolves assigned to the "Eastern Wolf" species (69%; data from Rutledge et al. 2010c; COSEWIC 2015).
[30] Resilience is the ability of a population to recover from a disturbance. Resilience is influenced by population size, level of genetic diversity, as well as characteristics of the species and its habitat.
[31] Redundancy is the presence of multiple populations of the species to guard against catastrophic loss.

In the assessment of the success of the plan, the management objective may be revisited or further specified in light of new information on the taxonomy, abundance or distribution of the species.

6. Broad Strategies and Conservation Measures

6.1 Actions Already Completed or Currently Underway

The following actions have been completed or are currently underway to contribute to the conservation of the Eastern Wolf in Canada.

- Eastern Wolves in and around Algonquin Provincial Park, in Ontario, have been the subject of research and monitoring since the 1960s. As a result, there is an exhaustive collection of data on the ecology, population dynamics and genetics of the wolves in this area (Forbes and Theberge 1992, 1995, 1996a, 1996b; Theberge et al. 1994, 2006; Norris et al. 2002; Grewal et al. 2004; Theberge and Theberge 1998, 2004; Mills 2006; Argue et al. 2008; Mills et al. 2008; Patterson and Murray 2008; Rutledge et al. 2010c, 2010e, 2011, 2015, 2016; Vucetich and Paquet 2010; Benson et al. 2012, 2013, 2014, 2015; Benson and Patterson 2013).
- Ecological data have been collected concerning wolves in Ontario outside Algonquin Provincial Park. These data have contributed greatly to our understanding of the distribution, behaviour, ecological role and genetics of the Eastern Wolf as well as of the factors that influence hybridization (Schmitz and Kolenosky 1985; Sears et al. 2003; Wheeldon 2009; Wheeldon and White 2009; Wilson et al. 2009; Holloway 2009; Loveless 2010; Rutledge 2010a; Rutledge et al. 2010b 2010d, 2016; Benson et al. 2012).
- In 2001, a ban on the harvesting of wolves was enacted in 40 townships surrounding Algonquin Provincial Park and in three townships located within the park (one of which overlaps the park boundary and is included in the 40 townships referred to above). This ban was extended in 2004 to include Eastern Coyotes and other coyote species owing to the difficulty distinguishing them morphologically from Eastern Wolves. The regulations governing harvesting were also amended in other areas of central and northern Ontario in order to better manage and conserve wolf populations. In 2016, the ban on the harvesting of wolves, Eastern Coyotes and other coyotes was extended to three additional areas, namely the townships in and around Kawartha Highlands, Queen Elizabeth II Wildlands and Killarney provincial parks (OMNRF 2016).
- Under a phase-out policy on trapping, trapping of wolves will be eliminated from one-third of the remaining Ontario provincial parks where it is currently permitted (COSEWIC 2015).
- Forest management on public lands in Ontario takes the habitat needs of the Eastern Wolf into account, either directly by restricting logging operations near known dens and rendezvous sites, or indirectly by creating habitat for its prey (White-tailed Deer, Moose and Beaver). The Ontario Ministry of Natural Resources and Forestry has published the *Forest Management Guide for*

Conserving Biodiversity at the Stand and Site Scales (OMNR 2010a) and the *Forest Management Guide for Great Lakes-St. Lawrence Landscapes* (OMNR 2010b), which provide information about creating and conserving habitat.

- Although few data have been published on the relationships of the Eastern Wolf with its habitat, research has been conducted in Algonquin Provincial Park with a view to determining the effects of the management of forests and other landscape components on the habitat use and hunting practices of wolves (Loveless 2010). Factors having an impact on territory size and competition for resources between Eastern Wolf packs have also been studied (Arseneau 2010). The influence of the landscape on hybridization dynamics was also the subject of a large-scale study in certain parts of Quebec and Manitoba (Stronen et al. 2010) and, on a smaller scale, within and near Algonquin Provincial Park by researchers from Trent University and from the Ontario Ministry of Natural Resources (Benson et al. 2012).
- In partnership with the University of Sherbrooke, La Mauricie National Park conducted a study between 2000 and 2003 with the goal of gaining a better understanding of the ecology of wolves (including the Eastern Wolf) in the park and surrounding area (Villemure 2003; Villemure and Fiesta-Bianchet 2004). These studies prompted Parks Canada to develop a conservation strategy for wolves in and outside La Mauricie National Park (Villemure and Masse 2005).
- Research has also been conducted by the University of Montreal on the extent of hybridization and the distribution of the Eastern Wolf in Canada (Stronen et al. 2012a, 2012b; Rogic et al. 2014), in partnership with Parks Canada, Environment and Climate Change Canada, the Société des établissements de plein air du Québec and the Quebec Department of Forests, Wildlife and Parks. This research has made it possible to document the presence of Eastern Wolves in Mont-Tremblant National Park and surrounding area and in La Mauricie National Park and surrounding area.
- The Wolf Lake Anishinabeg community has launched a project combining traditional knowledge and scientific research on the wolf, including surveys, DNA, telemetry tracking, population studies) in the Maganasipi River watershed in Quebec.
- Ontario Parks has instituted an educational program in Algonquin Provincial Park aimed at informing the general public about wolf ecology and at changing the public perception of this species, including a communication program on the unique aspects of the Eastern Wolf, as well as the ecology of wolves and their interactions with humans. In addition, this program helps provide information on the presence of wolves along the Highway 60 corridor in Algonquin Provincial Park (Manseau et al. 2003). Over 168,500 people participated in the Wolf Howl program in Algonquin Provincial Park between 1960 and 2016 (LeGros pers. comm. 2017), and this activity has been designated a “Canadian Signature Experience” by Destination Canada (formerly the Canadian Tourism Commission) (Steinberg, pers. comm. 2017).
- The wolf is the emblematic animal of Mont-Tremblant National Park and a management plan for habituated wolves (wolves that have become tolerant or accustomed to humans or human activities) has been developed (Tennier 2008).

An annual program of auditory surveys and an educational program have also been developed.
- In 2015, the Société des établissements de plein air du Québec, in collaboration with the Quebec Department of Forests, Wildlife and Parks and the Université du Québec à Rimouski, initiated a study on the canids of Mont-Tremblant National Park, including the Eastern Wolf. The study should enhance the understanding of the genetic identity of canids and their use of the area.
- Since the “Algonquin Wolf” was designated as Threatened, the Ontario Ministry of Natural Resources and Forestry has been working on a recovery strategy for this taxon.

The following actions have been taken or are underway in order to contribute to the conservation of wolves in Ontario, Quebec, Manitoba, Saskatchewan and the Maritimes. Consequently, they are likely to benefit the Eastern Wolf or to help further knowledge of the species.

- Several ecological studies have been conducted on wolf populations in Quebec and their distribution (e.g., Messier 1984, 1985, 1987; Messier and Crête 1985; Potvin 1987; Potvin et al. 1988; Jolicoeur 1998; Jolicoeur and Hénault 2002, 2010; Larivière et al. 2000; Rateaud et al. 2001; Villemure and Festa-Bianchet 2002; Villemure 2003; Villemure and Masse 2004; Houle 2008; Houle et al. 2010; Lesmerises 2012). Once current and future genetic research has determined the distribution of Eastern Wolves in Quebec, it will be possible to interpret and use the results of these studies in an Eastern Wolf management context.
- The Quebec Department of Forests, Wildlife and Parks is continuing to collect data on large canids captured in traps in order to document their morphologic and genetic profile.
- The Quebec Department of Forests, Wildlife and Parks conducts biennial assessments of harvesting pressure on wolves (all species combined) by determining the number of wolf pelts sold or traded in various parts of the province and compares them against wolf population estimates (Jolicoeur and Hénault, pers. comm. 2010).
- The Nionwentsïo Office (Huron-Wendat Nation) gathered contemporary knowledge about wolves from Huron-Wendat trappers (Bureau du Nionwentsïo 2016).
- The Ontario Ministry of Natural Resources and Forestry released a Strategy for Wolf Conservation in Ontario (OMNR 2005b).
- Research has been underway since 2010 in northern Ontario on the ecological relationships between wolves and moose (Vander Vennen et al. 2016) and between wolves and caribou (Patterson, comm. pers. 2009) and on the factors that affect wolf density (Kittle et al. 2015).
- Genetic research conducted in Manitoba has provided information on wolves in Duck Mountain Provincial Park and Riding Mountain National Park (Stronen 2009; Stronen et al. 2010; 2012a; b) as well as on the migratory patterns of wolves to and from this province (Crichton, pers. comm. 2010).

- Genetic and isotopic analyses were performed on a canid captured near Caraquet, New Brunswick, which turned out to be a Great Lakes–Boreal Wolf (McAlpine et al. 2015).
- The analysis of tissue samples provided by Paul Paquet (Saskatchewan) to the University of Montreal laboratory made it possible to validate information on the distribution of the genetic material of wolves in Saskatchewan (Stronen, pers. comm. 2011).
- Parks Canada studied the attitudes and perceptions of residents, hunters and trappers in the area of La Mauricie National Park toward wolves (Parks Canada 2007) and developed and instituted an educational program at the park on the importance of wolves aimed at modifying public perceptions of them (Bath 2006; Leith 2007; SOM Inc. 2007; TNS Inc. 2007a, 2007b). Education and awareness efforts are under way.
- The attitudes of farmers toward wolves in the area around Riding Mountain National Park in Manitoba and the factors that can influence these attitudes have also been studied (Stronen et al. 2007).
- The group Midwest Wolf Stewards has met annually since the late 1980s to discuss wolf conservation in the Great Lakes region. Meeting participants include representatives of provincial and federal organizations, state agencies and non-governmental organizations as well as First Nations interested in the management of wolves in the Great Lakes region.
- The Quebec Department of Forests, Wildlife and Parks has published and implemented management plans for Moose (since 1994; Lefort and Massé 2015) and for White-tailed Deer (since 1996; Huot and Lebel 2012) in order to manage cervid populations, which are an important component of the Eastern Wolf's diet.

6.2 Broad Strategies

The broad strategies of this management plan are described below. They are not presented in order of priority. The priority is identified in relation to the conservation measures (see section 6.3 *Conservation Measures*).

1. Eliminate or reduce the main threats to the species and its habitat in Canada.
2. Increase the awareness, education and engagement of key stakeholders in Eastern Wolf conservation and promote research initiatives.
3. Conduct surveys, clarify certain demographic parameters and monitor the distribution and population of the Eastern Wolf.
4. Address knowledge gaps that need to be filled to manage the Eastern Wolf (e.g., taxonomy, habitat and threats).

6.3 Conservation Measures

The conservation measures, the associated priority and a proposed implementation timetable for applying the broad strategies are presented in Table 2.

Table 2. Conservation Measures and Implementation Schedule

Conservation and Management Measures	Priority[a]	Threats or Concerns[b]	Timeline
1. Broad strategy: Eliminate or reduce the main threats to the species and its habitat in Canada			
1.1 Institute or continue to implement management measures that reduce the likelihood of introgression by the Eastern Coyote or by other large canid species in areas in which the Eastern Wolf occurs.	High	3	2025
1.2 Where necessary and as applicable, increase the size of protected areas in which the Eastern Wolf occurs, or establish buffer zones including specific management measures that promote conservation of the species.	High	2, 3	2025
1.3 Identify dispersal corridors and potential areas of colonization in the area of occupancy of the Eastern Wolf in order to plan and implement measures that reduce the human footprint (e.g., roads, agriculture) to thresholds acceptable for the species.	High	1, 5	2020
1.4 Encourage the creation, conservation and stewardship of healthy forests or forest ecosystems in the species' area of occurrence that will contribute to ensuring the natural predator-prey dynamics of the Eastern Wolf.	High	1, 3, 4, 5, 6, 9	2025
1.5 Consider the needs of the Eastern Wolf in the management plans and policies that apply to public lands, environmental assessments, and land use planning initiatives (e.g., forestry, mines, agriculture, energy) in areas in which the species occurs.	High	1, 2, 4, 5, 6, 9	Ongoing
1.6 Promote and support the application of existing acts and regulations that help to reduce threats to the Eastern Wolf in areas in which the species occurs.	High	1, 2, 3, 4, 5, 6	Ongoing
1.7 Where trapping of large canids is authorized, promote the use of humane trapping techniques.	Medium	2	Ongoing
1.8 Develop and apply best management practices to reduce the number of vehicle-wolf collisions.	Medium	1	Ongoing
1.9 In recreational/tourism areas, plan and implement activities designed to minimize disturbance of the Eastern Wolf.	Medium	6	Ongoing
1.10 Develop and apply management measures that target White-tailed Deer, Moose and Beaver harvesting rates in order to maintain the natural predator-prey dynamics of the Eastern Wolf.	Medium	9	Ongoing
1.11 Encourage the development, or improvement, and application of acts, regulations or policies where deemed necessary.	Medium	1, 2, 3, 4, 5, 6	2020

Conservation and Management Measures	Priority[a]	Threats or Concerns[b]	Timeline
2. Broad strategy: Increase awareness, education and engagement of key stakeholders in Eastern Wolf conservation and promote research initiatives			
2.1 Study the attitudes and perceptions of key stakeholders (e.g., farmers, trappers, hunters) with respect to the wolf in the range of the Eastern Wolf, and develop education and awareness programs aimed at increasing their tolerance.	High	2, 4, 5, 6	2025
2.2 Educate and raise the awareness of communities that coexist with the Eastern Wolf (e.g., farmers, trappers, hunters) about the status of the species and practices compatible with persistence of the species.	High	2, 4, 5, 6	Ongoing
2.3 Maintain or develop initiatives designed to provide key stakeholders with information on the presence of the wolf at the local scale (e.g., citizen science natural resources monitoring program)	High	10	2025
2.4 Institute or continue initiatives that promote the engagement and cooperation of governments, First Nations and key stakeholders (e.g., non-governmental organizations, private land owners, forest companies) in Eastern Wolf conservation efforts (e.g., at the landscape scale).	High	1, 2, 3, 4, 5, 6, 7	2020
2.5 Promote and support research and knowledge transfer initiatives, including traditional ecological knowledge related to the Eastern Wolf.	High	10	Ongoing
2.6 Raise public awareness about wolves and their habitat, in order to change negative attitudes and behaviour toward wolves (e.g., through the educational programs offered in the protected areas).	Medium	2, 5	Ongoing
3. Broad strategy: Conduct surveys, clarify certain demographic parameters and monitor the distribution and population of the Eastern Wolf			
3.1 Develop and promote the use of standardized protocols (e.g., data collection and processing, assignment tests) and databases.	High	10	2020
3.2 Using standardized genetic assignment tests, conduct surveys in the range of the Eastern Wolf and adjacent areas, particularly in previously unsurveyed suitable habitat.	High	10	2020
3.3 Estimate local densities of Eastern Wolf populations at known sites.	High	10	2020
3.4 Maintain a program for monitoring the Eastern Wolf population in order to identify population trends in Algonquin Provincial Park, and initiate such monitoring programs at other important occupied sites within the species' range.	High	10	2025
3.5 Obtain a more precise estimate of the Eastern Wolf population in Canada and of the effective population size throughout the species' range.	High	10	2025

Conservation and Management Measures	Priority[a]	Threats or Concerns[b]	Timeline
3.6 Establish a system for monitoring distribution based on the area of occupancy of the Eastern Wolf.	Medium	10	2020
3.7 Locate the areas of overlap between the Eastern Wolf and the "Eastern Coyote" (*C. latrans* x *C.* sp. cf. *lycaon*) and the "Great Lakes–Boreal Wolf" (*C. lupus* x *C.* sp. cf. *lycaon*) in order to target areas in which efforts to reduce hybridization should be focused.	Medium	10	2025
4. Broad strategy: Address knowledge gaps that need to be filled to manage the Eastern Wolf (e.g., taxonomy, habitat and threats)			
4.1 Estimate the number of Eastern Wolves harvested by trapping and hunting activities and the impact of the harvest rate on the Eastern Wolf population.	High	2, 10	2020
4.2 Assess the role played by occupied sites other than Algonquin Provincial Park in terms of the conservation of naturally regulated Eastern Wolf populations, and determine whether buffer zones with a ban on wolf harvesting around these protected areas are necessary to ensure adequate conservation of Eastern Wolf packs.	High	10	2020
4.3 Study the factors that promote or reduce Eastern Wolf hybridization (e.g., habitat fragmentation, human-related mortality).	High	3, 10	2025
4.4 Determine the ecological conditions and thresholds that promote persistence of the Eastern Wolf (e.g., competition, predation, availability of prey, availability of dens, human density).	High	9, 10	2025
4.5 Determine the most appropriate spatial unit for Eastern Wolf management (e.g., Canadian range, local population range).	High	10	2025
4.6 Obtain and compare genetic samples from Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick and the United States in order to determine the genetic identity and relationships of the different species of the *Canis* genus and more accurately determine the range of the Eastern Wolf.	Medium	3, 10	2020
4.7 Determine whether the Eastern Wolf could be reliably identified by precise morphological characteristics.	Medium	10	2020
4.8 Conduct studies on habitat selection (e.g., determine and quantify the biophysical characteristics required for conservation of a pack) at different spatial scales (e.g., landscape, territory) for the Eastern Wolf.	Medium	10	2025
4.9 Obtain more detailed data on the aspects of Eastern Wolf biology for which knowledge is insufficient (e.g., survival rate, generation time, social structure, adaptability).	Medium	10	2025

Conservation and Management Measures	Priority[a]	Threats or Concerns[b]	Timeline
4.10 Estimate the number of incidental kills of Eastern Wolf (e.g., during hunting for Moose or White-tailed Deer).	Medium	2, 10	2020
4.11 Study the effect of roadkill on Eastern Wolf populations in the known area of occupancy.	Medium	1, 10	2025
4.12 Study the effect of landscape fragmentation (e.g., roads, agriculture, residential and commercial development) on the Eastern Wolf and its requirements in terms of connectivity.	Medium	1, 4, 5, 10	2025
4.13 Compile cases of wolf mortality within the Eastern Wolf's range that are associated with protecting human life or property, and make this information available in order to be able to identify and implement appropriate reduction and mitigation measures, where required.	Low	2	2025
4.14 Obtain more detailed data on the impact and current extent of threats posed by parasites and diseases on Eastern Wolf populations in Canada. If parasites and diseases constitute a significant threat for maintenance of Eastern Wolf populations, study the methods of transmission of parasites and diseases (e.g., by populations of other wildlife species or by domestic dogs) and develop techniques for mitigating their effects.	Low	7, 10	2025
4.15 Conduct the necessary studies in order to assess the anticipated direct and indirect effects of climate change or any other threats that could arise in the future on Eastern Wolf populations (e.g., habitat shifting and alteration, parasitic diseases, higher trophic level interactions).	Low	8, 10	2025

[a] "**Priority**" reflects the degree to which the measure contributes directly to the conservation of the species or is an essential precursor to a measure that contributes to the conservation of the species. High priority measures are considered those most likely to have an immediate and/or direct influence on attaining the management objective for the species. Medium priority measures may have a less immediate or less direct influence on reaching the management objective, but are still important for the management of the population. Low priority conservation measures will likely have an indirect or gradual influence on reaching the management objective, but are considered important contributions to the knowledge base and/or public involvement and acceptance of the species.

[b] **Threats** – 1) roads and railroads, 2) hunting and collecting terrestrial animals – hunting, trapping and poaching, 3) introduced genetic material – hybridization of the Eastern Wolf with the Eastern Coyote, 4) residential and commercial development, 5) agriculture, 6) recreational activities, 7) invasive/non-native alien species – diseases, parasites and domestic animals, 8) habitat shifting and alteration – climate change.
Concerns: 9) predator-prey dynamics (limiting factor), 10) knowledge gaps.

6.4 Narrative to Support Conservation Measures and Implementation Schedule

A number of specific characteristics of the Eastern Wolf must be taken into account in preparing a management strategy for the species. First, the current Canadian range of the Eastern Wolf is small compared to its historical range. Its expansion is limited by urbanization to the south within Ontario and Quebec and by the presence of the Grey Wolf or Great Lakes–Boreal Wolf to the north. The extent of occurrence of the Eastern Wolf also appears to be fragmented by areas of unsuitable habitat or by areas in which management measures are not compatible with the maintenance of Eastern Wolf packs. Second, the Eastern Wolf is a top predator, i.e., it is typically not a prey species of any other species and is therefore at the top trophic level of its ecosystem. Like most mammals that are top predators, Eastern Wolves occur in small densities in large areas of habitat and have a relatively long generation time. The management strategy for the species must therefore also be adapted to the characteristics of this type of predator, for example by promoting the conservation of large tracts of forest enabling them to meet their ecological needs, which includes ensuring the availability of their preferred prey. Like many top predators, the Eastern Wolf may also raise public safety concerns or fear on the part of the public.

In order to apply appropriate conservation measures, it is important to more accurately determine the current and historical range of the Eastern Wolf in Canada, along with the demographic data (e.g., wolf density). This will make it possible to implement the necessary monitoring to identify population and distribution trends. The use of standard sampling protocols and standardized databases will be of prime importance for clarifying uncertainties related to the status of Eastern Wolf populations and the species' Canadian range and for determining to what extent the Canadian population is resilient and redundant.

Given the knowledge gaps on Eastern Wolf population and distribution, which are due in part to uncertainties regarding the extent of hybridization with other species and hybrids of the genus *Canis* and to a lack of data, further studies will be required to resolve the taxonomic uncertainties and to manage the technical challenges associated with the need to identify the species by molecular analysis.

Knowledge gaps relating to the impact, scope, severity and timing of certain threats, including hunting, trapping and poaching, hybridization with Eastern Coyotes and road mortality, also need to be addressed. Certain characteristics of Eastern Wolf habitat and ecology also need to be further defined, including the ecological thresholds promoting viability of the population and the species' connectivity requirements.

Given the threat to the Eastern Wolf posed by hybridization with Eastern Coyotes, maintaining a viable Eastern Wolf population in Canada will require the elimination or reduction of several threats, including those associated with roads, hunting, trapping and poaching, which have an effect on hybridization with Coyotes (see section 4.2 *Threats Description*). At the same time, in Ontario and Quebec, integrated, large-scale management of species and wild hybrids of the genus *Canis* will be required to promote stable hybrid systems (see Bohling 2016). The threats that cause increased mortality or loss of suitable habitat will also have to be reduced or eliminated in order to ensure the viability of the population. More extensive use of certain conservation measures in the area of occupancy of the Eastern Wolf aimed at reducing or eliminating the primary threats (e.g., implement a ban on the harvesting of Eastern Wolves and Eastern Coyotes in some areas – see section 6.1 *Actions already completed or underway*) could thus contribute to the achievement of the management objective. Ensuring the well-being of Eastern Wolves must also be considered in territories where it could be harvested by trapping; the use of humane trapping techniques (AIHTS 1999; Proulx et al. 2012, 2015) should be advocated to minimize animal pain and suffering. Ensuring connectivity between occupied areas containing suitable unoccupied habitats in the surrounding area is also important, as it contributes to the natural expansion and genetic cohesion of the Eastern Wolf population in Canada.

Finally, the involvement of governments, First Nations and a wide range of stakeholders (e.g., non-governmental organizations, universities, private landowners, forest companies) will be critical to the implementation of many conservation measures. Transfer of knowledge (e.g., detailed genetic profile) to affected parties will be particularly important since many knowledge acquisition measures are set out in the implementation schedule (Table 2). The introduction of communications programs designed to improve the public's perception of wolves and to modify negative behaviours and attitudes toward wolves also appears to be very important, given that social acceptance is critical to reducing certain threats, such as the killing of Eastern Wolves out of fear or hatred.

7. Measuring Progress

Every five years, success in the implementation of this management plan will be measured against the following performance indicators:

1. The Canadian Eastern Wolf population is assessed as viable;
2. The current size of the Canadian range (extent of occurrence) is maintained (126,573 km^2).

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Appendix A: Additional Information on the Effects of Trapping on the Eastern Wolf Population in Canada

In Quebec, an analysis of the data on wolves harvested in furbearer management units indicates that 172 wolves on average were harvested each year between 2005-2006 and 2014-2015 (MFFP, unpub. data). During the 1990-1997 period, the estimated trapping harvest rates[32] in seven wildlife reserves in Quebec located, at least partly, in the area of occurrence of the Eastern Wolf, ranged from 1.2% (± 0.3; Mastigouche Wildlife Reserve) to 74.4% (± 23.8; Papineau-Labelle Wildlife Reserve) (Larivière et al. 1998). Furthermore, in the Papineau-Labelle Wildlife Reserve and surrounding area, where documented mortality from 1980 to 1984 was entirely of human origin and 83% of this mortality was attributable to harvesting (permitted in the area bordering the wildlife reserve), the annual survival rate of radio-collared wolves was 64% at a time when commercial trapping was banned in the reserve (Potvin 1987).[33] In La Mauricie National Park and surrounding area, where significant parts of wolf territories extend outside the park, the annual mortality rate of radio-collared wolves was 36% between 2000 and 2003, with 90% of these mortalities caused by trapping. Adult mortality totalled two deaths for every 13 wolf-years (15%) compared to eight pups for every nine wolf-years (89%), with most of these resulting from captures outside the park (Villemure 2003). Pups are often more vulnerable to trapping mortality than adults (Mech 1977; Fuller 1989; Jolicœur 1998), and juvenile Eastern Wolves are believed to be particularly vulnerable given that they typically disperse much earlier than what is reported in other wolf populations (Packard 2003; Mills et al. 2008). Since the early 1990s, there has been a downward trend in the number of fur pelts sold in Quebec (Hénault and Jolicoeur 2003; MFFP unpub. data). Given that the Eastern Wolf may be confused with the Eastern Coyote or the Grey Wolf and that the Eastern Wolf is not yet officially recognized by Quebec authorities, it is impossible to determine the proportion of Eastern Wolves in the harvest of wolves or Eastern Coyotes.

In Ontario, according to the records, the average number of wolves (all species combined) taken annually by trappers between 1971 and 2003 was 337, while the average number of coyotes taken annually was 994 (OMNR 2005a). In Algonquin Provincial Park and the surrounding townships, where wolf trapping and hunting have been banned since 2001, the proportion of human-caused mortality has fallen from 67% before the ban (1989-1999) to 16% after the ban (2002-2007). The survival rate and population density have not increased, however, owing to an increase in natural mortality rates; nonetheless, the proportion of packs containing unrelated individuals declined significantly, from 80% to 6% (Rutledge et al. 2010e).

[32] Percent trapping mortality, calculated from data on reported fur sales and regional estimates of wolf populations (Hénault and Jolicoeur 2003).[3233] Potvin (1987) Potvin (1987) reported that no difference had been observed in annual survival rates between age classes (pups, yearlings and adults (> 24 months)).
[33] Potvin (1987) Potvin (1987) reported that no difference had been observed in annual survival rates between age classes (pups, yearlings and adults (> 24 months)).

Appendix B: Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the *Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals*.[34] The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the Federal Sustainable Development Strategy's[35] (FSDS) goals and targets.

Conservation planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that the implementation of management plans may inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the management plan itself, but are also summarized below.

Eastern Wolf habitat conservation measures will probably have a beneficial effect on a number of other species that use similar habitats, particularly species that require extensive forested areas, including the Grey Wolf and the Great Lakes–Boreal Wolf. Conservation measures are also likely to benefit species that feed on the prey of the Eastern Wolf (Pimlott et al. 1969; Kolenosky 1972; Wilmers et al. 2003a, 2003b; Ripple and Beschta 2004). Table 3 provides a non-exhaustive list of species that may benefit from conservation measures targeting the Eastern Wolf.

[34] www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1
[35] www.ec.gc.ca/dd-sd/default.asp?lang=En&n=F93CD795-1

Table 3. Species that may benefit from Eastern Wolf conservation and management measures in the areas where the Eastern Wolf is present

Common Name	Scientific Name	SARA Status
Blue Jay	*Cyanocitta cristata*	Not at Risk
Common Raven	*Corvus corax*	Not at Risk
Grey Jay	*Perisoreus canadensis*	Not at Risk
Bald Eagle	*Haliaeetus leucocephalus*	Not at Risk
Grey Wolf	*Canis lupus*	Not at Risk
American Marten	*Martes americana*	Not at Risk
Fisher	*Martes pennanti*	Not at Risk
Red Fox	*Vulpes vulpes*	Not at Risk
Wood Turtle	*Glyptemys insculpta*	Threatened
Blanding's Turtle	*Emydoidea blandingii*	Threatened

Although some of the proposed conservation measures have benefits for the environment in general and have a positive impact on other sympatric native species, there could be consequences for species whose requirements differ from those of the Eastern Wolf. For example, the relationship between the Eastern Wolf and its main prey, White-tailed Deer, Moose and Beaver, could be modified. Research indicates that Eastern Wolves attack young and old individuals of White-tailed Deer (Pimlott et al. 1969) and Moose (Loveless 2010) populations to a disproportionate degree, supporting the theory that predation by wolves can be compensatory, reducing the number of old or sick individuals within the population, while healthy breeding animals have a higher survival rate. However, during periods of prey scarcity, this relationship may no longer be compensatory (Potvin et al. 1988; Delguidice et al. 2002). In areas where Moose have been hunted by humans, Eastern Wolves have increased their predation of Moose calves and juveniles (Loveless 2010). In addition, canids present in the extent of occurrence of the Eastern Wolf attack Woodland Caribou (*Rangifer tarandus caribou*), such as in the Laurentides Wildlife Reserve (Sebbane et al. 2008), but it has not yet been confirmed whether the canids are Eastern Wolves, Grey Wolves or Great Lakes–Boreal Wolves. A study on the relationship between wolves and caribou in northern Ontario was undertaken in 2010 (Patterson, pers. comm. 2009); the preliminary data suggest that the Grey Wolf is the main predator of Woodland Caribou in this area (Benson, pers. comm. 2011) and that the impact of the Eastern Wolf on Woodland Caribou populations would therefore be very limited. Moreover, certain conservation measures could also have an effect on Eastern Coyote populations present in the area of occurrence of the Eastern Wolf. Some measures leading to a reduction in canid mortality rates could benefit them, while others (e.g., focussed on habitat management) could limit their expansion.

Consequently, it is important that Eastern Wolf habitat management activities be planned from an ecosystem perspective and with input from responsible authorities through the development, of multi-species plans, ecosystem-based recovery strategies and area management plans that take into account the needs of the various species, including other species at risk. Many stewardship and habitat improvement activities undertaken for the benefit of the Eastern Wolf will be implemented through ecosystem-based management programs that take the needs of species at risk into account.