Ontario Species at Risk Evaluation Report for Algonquin Wolf (*Canis* sp.), an evolutionarily significant and distinct hybrid with *Canis lycaon, C. latrans,* and *C. lupus* ancestry

Committee on the Status of Species at Risk in Ontario

(COSSARO)

Assessed by COSSARO as THREATENED

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Final

Loup Algonquin (*Canis* sp.)

Le loup Algonquin (*Canis* sp.) est un canidé de taille intermédiaire qui vit en meute familiale et qui se nourrit de proies comme le castor, le cerf de Virginie et l'orignal. Le loup Algonquin est le fruit d'une longue tradition d'hybridation et de rétrocroisement entre le loup de l'Est (*Canis lycaon*) (appelé aussi *C. lupus lycaon*), le loup gris (*C. lupus*) et le coyote (*C. latrans*). Bien qu'il fasse partie d'un complexe hybride répandu, le loup Algonquin peut se différencier des autres hybrides, comme le loup boréal des Grands Lacs, parce qu'il forme une grappe discrète, sur le plan génétique, composée d'individus étroitement apparentés à partir de laquelle il est possible de faire des estimations de filiation présumée. De plus, selon les données morphologiques, il est généralement plus grand que les canidés de type *C. latrans* et plus petit que les canidés de type *C. lupus*, bien qu'une identification fiable nécessite des données génotypiques. En Ontario, le loup Algonquin est principalement confiné dans le parc provincial Algonquin ainsi que dans les régions avoisinantes, dont certaines sont protégées. Ces régions englobent le parc provincial Killarney au sud de la région caractéristique des Hautes-Terres de Kawartha. Les relevés plus éloignés sont relativement rares et vraisemblablement attribuables à des incidents de dispersion occasionnels sur de grandes distances. Comme le nombre total de canidés dans ce groupe génétique se chiffre probablement entre 250 et 1 000 individus matures, le loup Algonquin a été désigné comme une espèce menacée.

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Executive summary

The Algonquin Wolf (*Canis* sp.) is an intermediate-sized canid that lives in family-based packs and feeds on prey that includes Beaver, White-tailed Deer, and Moose. The Algonquin Wolf is the result of a long history of hybridization and backcrossing among Eastern Wolf (*Canis lycaon*) (aka *C. lupus lycaon*), Gray Wolf (*C. lupus*), and Coyote (*C. latrans*). Although part of a widespread hybrid complex, the Algonquin Wolf can be differentiated from other hybrids, such as the Great Lakes-Boreal Wolf, because it forms a genetically discrete cluster of closely related individuals from which estimates of inferred ancestry can be derived. In addition, morphological data identify it as being generally larger than *C. latrans*-type canids, and smaller than *C. lupus*-type canids, although reliable identification requires genotypic data. The Algonquin Wolf is largely restricted in Ontario to Algonquin Provincial Park plus surrounding areas, some of which are protected. These include an area from Killarney Provincial Park south to Kawartha Highlands Signature Site. More distant records are relatively infrequent and likely attributable to occasional long-distance dispersal events, The total number of canids in this genetic group likely numbers between 250 and 1000 mature individuals, and therefore it has been designated as Threatened.

1. Background information

1.1. Current designations

The closest comparison is with *Canis lupus lycaon* or *Canis* sp. cf. *lycaon*, the current designations of which are provided below:

- GRANK: G4G5TNR, Eastern Wolf (*Canis lupus lycaon*) (NatureServe 2015)
- COSEWIC: Threatened, Eastern Wolf (*Canis sp. cf. lycaon*) (COSEWIC 2015)
- SARA: Special Concern (Schedule 1), Eastern Wolf (*Canis lupus lycaon*) (SARA 2015)
- ESA: Special Concern, Eastern Wolf (*Canis lupus lycaon*) (Ontario Regulation 230/08 2015)
- SRANK: S4, Eastern Wolf (*Canis lupus lycaon*) (NatureServe 2015)

1.2. Distribution in Ontario

The Algonquin Wolf is discontinuously distributed in the mixed Great Lakes-St. Lawrence Forest of central Ontario, and is concentrated in various protected areas (Figures 1 and 2). It occurs from Killarney Provincial Park east to Algonquin Provincial Park (hereafter APP) and the Ottawa Valley, south to Fenelon Falls and Buckhorn, with rare records west to the Sault Ste. Marie area.

1.3. Distribution and status outside Ontario

Outside of Ontario the Algonquin Wolf (identified on the basis of 80% or higher inferred ancestry with wolves in Algonquin Provincial Park; see Section 2) occurs primarily in southern Quebec north of the St. Lawrence River (COSEWIC 2015). Researchers have identified a taxon as Eastern Wolf (*Canis lycaon*) in the western Great Lakes region of the USA (Mech 2010; Fain et al. 2010), but these populations are thought to be primarily hybrids between *Canis lupus* and *C. lycaon* (aka *C. lupus lycaon*) (Wheeldon and White, 2009; Wheeldon et al. 2010a; Fain et al. 2010; Rutledge et al. 2015), and population genetic comparisons between Algonquin and Great Lakes Wolves do not suggest that the two groups share high recent ancestry (L. Rutledge, T. Wheeldon, pers. comm., 2015; Rutledge et al. 2015; although see vonHoldt et al. 2011; Rutledge et al. 2012; Monzon et al. 2014; Rutledge et al. 2015 for some of the complexities surrounding this issue). Mitochondrial and Y chromosome haplotypes that have been associated with *C. lycaon* have been found as far west as Saskatchewan, as far east as Quebec, and across broad regions of the northeastern United States (Wilson et al. 2000; Grewal et al. 2004; Koblmüller et al. 2009; Fain et al. 2010; Stronen et al. 2010, 2012; Way et al. 2010), but these likely represent historical hybridization events, and the descendants of these hybrids are not closely related to the Algonquin Wolves.

Figure 1. Distribution of recent Algonquin Wolf records in Ontario.

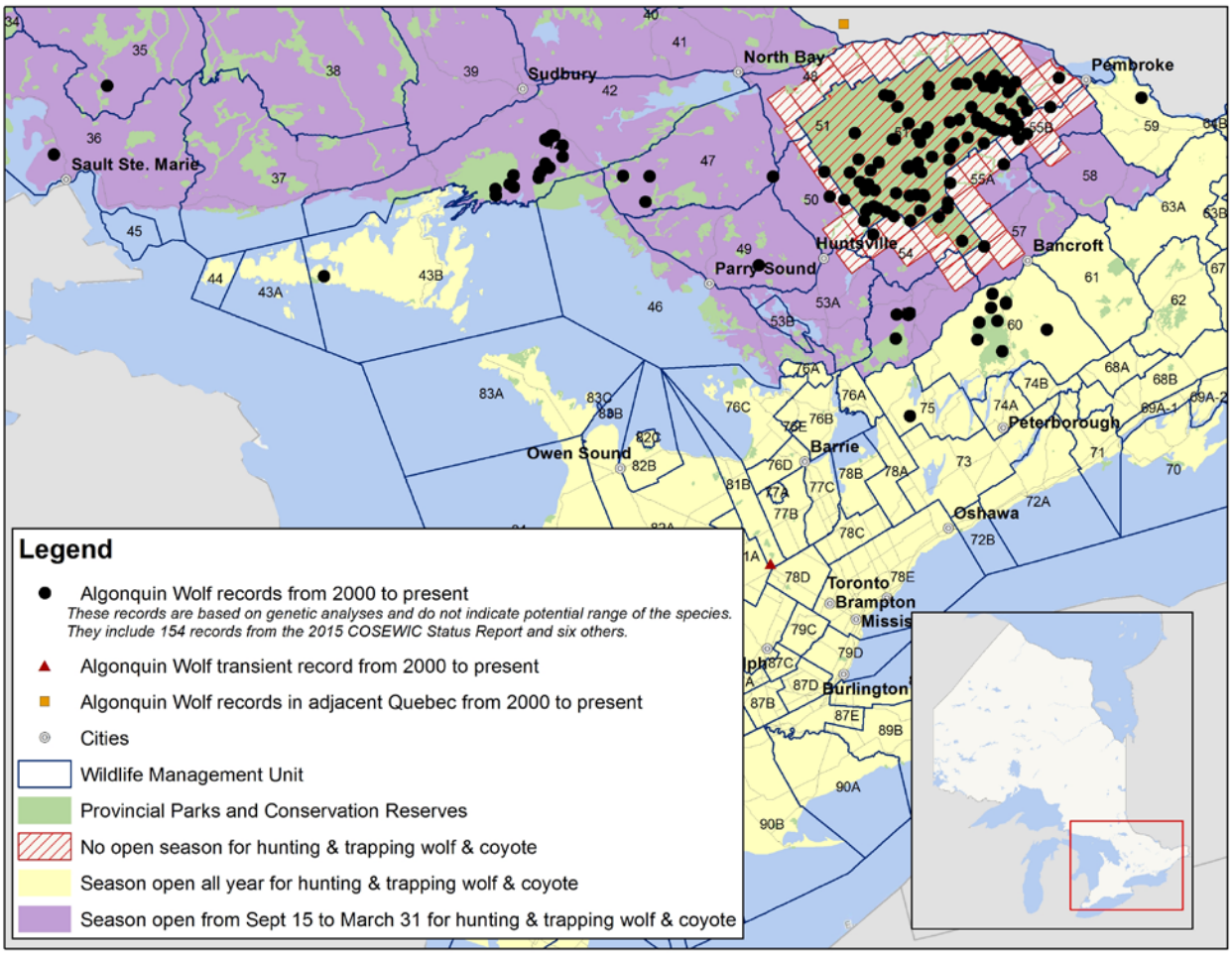
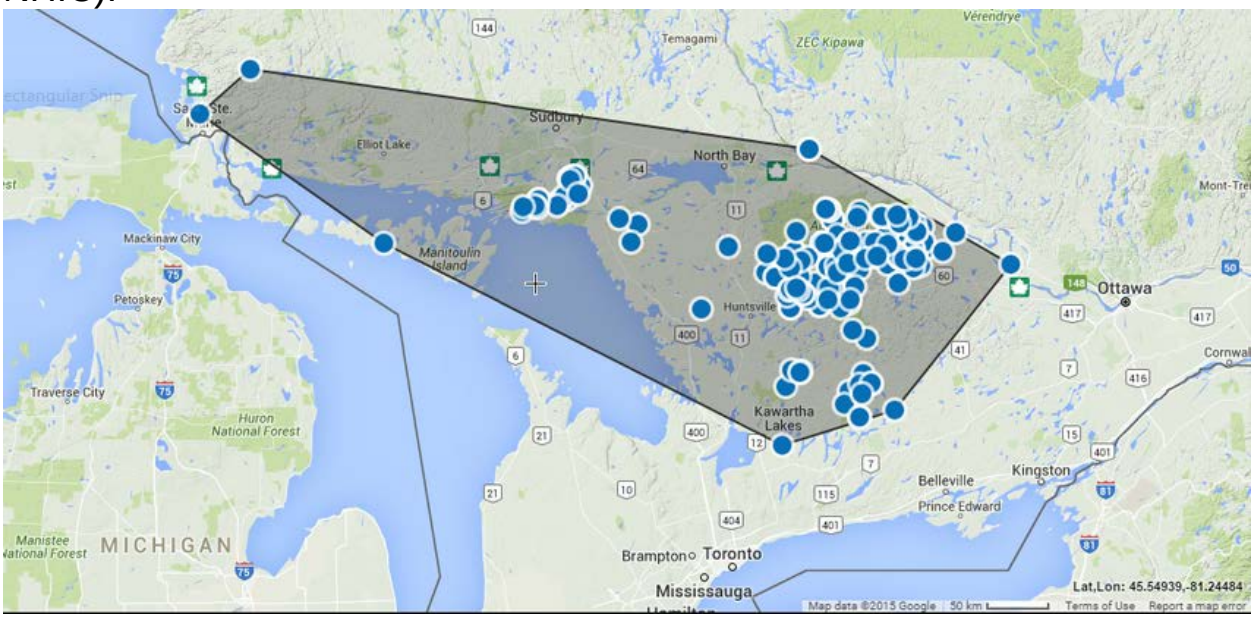


Figure 2. Area from which EOO was calculated as 79,710 km^2 (source: NHIC).



1.4. Ontario conservation responsibility

Ontario represents the majority of the global range of Algonquin Wolf, with approximately 63% of the extent of occurrence (EOO) in Ontario. Ontario represents approximately 65% of the population of mature individuals estimated by COSEWIC (Table 2; 2015).

1.5. Direct threats

Although human-caused mortality is identified as a significant threat, a reduction in hunting and trapping mortality from 67% to 16% resulting from a ban in townships in and adjacent to Algonquin Park in 2001 was followed by a comparable increase in natural mortality rates (COSEWIC 2015). Although the provincial government is currently proposing to loosen restrictions governing the hunting of coyotes in northern Ontario (north of wildlife management unit 42), nothing is proposed to change in or south of wildlife management unit 42 (Killarny-Sudbury-North Bay). There are areas in southern and central Ontario which currently house some Algonquin Wolves and where neither wolves nor coyotes are protected from hunting, but that has been the case for more than a decade, and in these areas hunting and trapping remain a significant threat. However, although there is a threat from hunting and trapping to Algonquin Wolves in some areas this threat is not increasing, other than for those few animals north of the continuous distribution in areas like Sault Ste. Marie (B. Patterson, pers. comm., 2016). Rabies and mange have been significant mortality factors on occasion, but are not consistent threats.

The Threats Calculator in COSEWIC (2015) indicated that high threats are hunting and trapping, associated with high road densities that facilitate human access. Medium

threats include road-related mortality. Residential housing development is considered a low threat, related more to a potential increase in human-related mortality than to quantitative habitat loss (COSEWIC 2015).

1.6. Specialized life history or habitat use characteristics

The Algonquin Wolf is not restricted to any specific habitat type, although it is most abundant in areas with abundant prey such as Moose (*Alces alces*), White-tailed Deer (*Odocoileus virgianus*) and Beaver (*Castor canadensis*), and low levels of human-caused mortality (COSEWIC 2015). Den and rendezvous sites are typically located in conifer-dominated landscapes near a permanent water source with suitable soil such as sand for excavation (COSEWIC 2015).

2. Eligibility for Ontario status assessment

2.1. Eligibility conditions

2.1.1. Taxonomic distinctness

Yes. The wolves from Algonquin Provincial Park have previously been identified as Eastern Wolves (Rutledge et al. 2010a; Benson et al. 2012; COSEWIC 2015), which in turn have been identified as either *Canis lycaon* (Rutledge et al. 2010a; Benson et al. 2012), *Canis* sp. cf. *lycaon* (COSEWIC 2015), or *Canis lupus lycaon* (Van Zyll de Jong and Carbyn 1999). Much of the debate about the taxonomy of *Canis* is associated with the arrival of the Coyote (*Canis latrans*) into eastern North America. In a continental-scale invasion, Coyotes from the Prairie region of North America expanded northward and eastward; the first record in southeastern Ontario was in 1919 (Nowak 1979). These small *Canis* (e.g., adult male averages of 13 - 14 kg in different parts of the central Prairies [Parker 1995]) bred with a larger *Canis* in the Great Lakes region and produced an intermediate-sized animal (e.g., adult male averages of 14.6 - 21 kg in different parts of northeastern North America [Parker 1995; Villemure and Jolicoeur 2004]). The new animal, named the Eastern Coyote, then established itself across eastern Canada, reaching Québec in 1944, Nova Scotia in the 1970s, and Newfoundland in 1985 (Parker 1995; Naughton 2012).

There is general consensus that the historical and continued sympatric distributions of *C. lycaon, C. lupus,* and *C. latrans* has led to widespread and longstanding hybridization, backcrossing, advanced-generation hybridization, and introgression among these three taxa in eastern North America (Grewal et al. 2004; Rutledge et al. 2010a; Way et al. 2010; Wheeldon et al. 2010b; Wilson et al. 2012; Benson et al. 2012; Rutledge et al. 2012), and this introgression may also have involved genes from domestic dogs (*C. lupus familiaris*) (Wilson et al. 2012; Wheeldon et al. 2013; Monson et al. 2014). This explains some of the confusion regarding the identity and distribution of Algonquin Wolves (see Section 1.3).

Morphological data provide a potential method for identifying putative Algonquin Wolves, as there are numerous records of canids in Ontario that are intermediate in size

to Gray Wolves and Coyotes (e.g. Kolenosy and Standfield 1975; Theberge and Theberge 2004; Rutledge et al. 2010b; Benson et al. 2012). The Algonquin Wolf phenotype is a continuum of sizes that are generally intermediate to *C. lupus* and *C. latrans* (Benson et al. 2012), and this intermediate size range has been attributed to hybridization between Gray Wolves and Coyotes (Nowak 1979, 1995), or a response to changes in prey size (Young and Goldman 1944; Kolenosky and Standfield 1975; Schmitz and Kolenosky 1985; Brewster and Fritts 1995; Nowak 1995). The hybrid wolves of APP are overall intermediate in size to *C. lupus*-like canids and *C. latrans*-like canids, typically weighing < 30 kg (Theberge and Theberge 2004). Based on data collected in Algonquin Park from 2002 - 2007, female average yearling weight is 18.1 kg and female average adult weight is 24.2 kg, whereas male average yearling weight is 23.5 kg and average adult weight is 29.3 kg (COSEWIC, 2015). Average adult shoulder height for Algonquin Wolves is 63.8 cm for females and 70.0 cm for males (Brent Patterson pers. comm. cited in COSEWIC [2015]). However, size ranges do have some overlap between Algonquin Wolves, *C. latrans*-like canids, and *C. lupus*-like canids (B. Patterson, pers. comm. 2015), and therefore size is not a completely reliable identifier.

To date, the most definitive assignments of individuals to the Algonquin Wolf population have been based on population genetic data. Researchers have used these data, typically microsatellite allele and genotype frequencies, combined with programs such as Structure (Pritchard et al. 2000; Falush et al., 2003; Hubisz et al. 2009), to first identify the most plausible number of genetic clusters within any given data set; in this context, clusters represent groups of potentially interbreeding individuals that each conform to parameters such as Hardy-Weinberg equilibrium and linkage equilibrium. Once such clusters have been identified, membership to each cluster can be estimated by inferred ancestry to each cluster. COSEWIC (2015) used an inferred ancestry coefficient (Q) of 0.8 or higher as the threshold for identifying animals as Eastern Wolves, but which we are here referring to as Algonquin Wolves. There is no known 'pure' Eastern Wolf individual or population that can be used as a genetic reference, and it is therefore most accurate to say that the Q value of 0.8 or higher can be used to identify wolves with a high level of inferred ancestry to the Algonquin Wolf population. Indeed, the COSEWIC report (2015) acknowledges that '…we lack enough specimens that have been collected before Coyotes were present to characterize a pure Eastern Wolf'. This lack of reference material, combined with a well-documented pattern of hybridization, admixture, and introgression among Ontario canids (see above), means that the Algonquin Wolf is most appropriately described as a hybrid group that collectively represents a genetically discrete cluster with distinct morphological characteristics. For this assessment, we therefore considered individuals with an inferred ancestry of 0.8 or higher (following Structure analyses) to the APP wolves to belong to the genetic cluster that largely inhabits APP, in other words we considered those individuals to be Algonquin Wolves.

Geneclass (Piry et al. 2004) assignment tests supplemented the Structure analyses by using the Algonquin reference population of 88 canids with Q>0.8 (based on Structure; Rutledge et al. [2010]) to determine whether or not canids from an additional 105 individuals sampled from outside APP were assigned to the APP population. Nineteen individuals from outside the park were assigned to the APP population by Geneclass, whereas 33 individuals from the same group were identified by Structure as having an

inferred ancestry of 0.8 or greater with the APP population (T. Wheeldon, L. Rutledge, B. Patterson, unpublished data). This discrepancy had a negligible impact on both the extent and the area of occurrence of Algonquin wolves, and although it did reduce by 14 the number of wolves outside APP identified as having high ancestry with the Algonquin Wolf, the uncertainty in total population size associated with incomplete sampling outside APP means that the difference in inferred numbers of Algonquin wolves outside the park based on the two methods of analysis (Structure versus Geneclass) is unlikely to have an appreciable impact on estimates of total population size. Because both methods (Structure and Geneclass) are model-based, both carry sets of assumptions, and should be viewed as complementary analytical approaches. In this case, the outcomes from each type of model were of sufficient similarity to strengthen our overall conclusions regarding distribution and population size.

Finally, an unpublished study found that some alleles in the major-histocompatibility complex (MHC), a group of genes involved in immune response, were found in Algonquin Wolves but not in either Eastern Coyotes or Grey Wolves (Kennedy pers. comm. to L. Rutledge, 2012). Although preliminary, these data further reinforce the conclusion that the Algonquin Wolf comprises an evolutionarily distinct unit.

Collectively, the data outlined above support the premise that the Algonquin Wolf conforms to the broad definition of species defined by *Endangered Species Act, 2007* (ESA), which states that “species” means a species, subspecies, variety or genetically or geographically distinct population of animal, plant or other organism, other than a bacterium or virus, that is native to Ontario”. Following this definition, the genetic distinctness of the Algonquin Wolf, combined with its native status, makes it suitable for Ontario status assessment. COSSARO has named this taxon Algonquin Wolf (*Canis* sp.) to a) differentiate it from other populations that have been labelled ‘Eastern Wolf’ (e.g. hybrids in the Great Lakes region, which are genetically distinct from the Algonquin Wolf; L. Rutledge and T. Wheeldon, pers. comm.), and b) acknowledge the hybrid ancestry of this evolutionarily significant unit. Although COSSARO has chosen to use a different name than COSEWIC has used (Eastern Wolf), these two taxa are considered to have the same genetic characteristics.

2.1.2. Designatable units

No. There is a single genetic cluster to which the majority of APP canids are assigned at an inferred ancestry of 0.8 or higher.

2.1.3. Native status

Yes. The Algonquin Wolf shares ancestry with *C. lycaon,* which is native to Ontario, with records dating back to the 1700s (COSEWIC 2015). The long-term presence of an intermediate-sized canid in eastern Canada is also confirmed by Aboriginal Traditional Knowledge. Gray Wolves are also considered native to Ontario, and Eastern Coyotes have been in Ontario for at least 100 years. Therefore, all of the taxa within this hybrid complex are native to Ontario.

2.1.4. Occurrence

The current Ontario distribution of the Algonquin Wolf is in central Ontario, with core concentrations in APP and surrounding townships (Figure 1). The Algonquin Wolf also occurs in and around Killarney Provincial Park, Kawartha Highlands Signature Site, Queen Elizabeth II Wildlands, and the Magnetawan area (Rutledge et al. 2010a; Benson et al. 2012; Wilson et al. 2009; B. Patterson, pers. comm.). In addition, there are a few records from Manitoulin Island and the area around Sault Ste. Marie. This distribution is based on genetic analysis (Structure) of 154 individuals as mapped in COSEWIC (2015) and six additional analyzed records from the Natural Heritage Information Centre.

2.2. Eligibility results

Algonquin Wolf is eligible for status assessment in Ontario.

3. Ontario status assessment

3.1. Application of endangered/threatened status in Ontario

3.1.1. Criterion A – Decline in total number of mature individuals

Does not apply/insufficient information. The Algonquin Wolf population appears to be stable (COSEWIC 2015).

3.1.2. Criterion B – Small distribution range and decline or fluctuation

Does not apply. Exceeds thresholds for EOO (79710 km^2) and IAO (>10000 km^2).

3.1.3. Criterion C – Small and declining number of mature individuals

Does not apply. No evidence of a population decline.

3.1.4. Criterion D – Very small or restricted total population

Threatened. The Algonquin Wolf meets D1 because the estimated population of mature individuals is less than 1000. COSEWIC (2015) estimated that the minimum number of mature individuals in Ontario is 154, and the estimated maximum number of Algonquin Wolves inferred from sampled sites in Ontario is 488. However, under-sampling in some areas, e.g. between Georgian Bay and APP (L. Rutledge, pers. comm. 2015), combined with the need to genotype individuals in order to identify Algonquin Wolves, has almost certainly led to an underestimation of the Algonquin Wolf population size, and the actual number is most likely somewhere between 250 and 1000.

3.1.5. Criterion E – Quantitative analysis

Does not apply/inconclusive. Reanalysis of a PVA which predicted extirpation of APP

wolves (Theberge et al. 2006) concluded that wolves in APP are unlikely to decline significantly over the next 20 years (Patterson and Murray, 2008).

3.2. Application of Special Concern in Ontario

Not applicable.

3.3. Status category modifiers

3.3.1. Ontario's conservation responsibility

Ontario represents much greater than 25% of the global range of Eastern Wolf as described in COSEWIC (2015), and thus this status modifier could potentially apply. .

3.3.2. Rescue effect

Rescue effect is unlikely because individuals from geographically distant locations are unlikely to genetically cluster with APP wolves. Some rescue effect from Quebec populations may be feasible, although risks of human-caused mortality and hybridization with coyotes increase outside of protected areas.

3.4. Other status categories

3.4.1. Data deficient

Does not apply.

3.4.2. Extinct or extirpated

Does not apply.

3.4.3. Not at risk

Does not apply.

4. Summary of Ontario status

The Algonquin Wolf, a hybrid with *Canis lycaon, C. latrans,* and *C. lupus* ancestry, is classified as Threatened in Ontario under criterion D1.

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Appendix 1: Technical summary for Ontario

Species: Algonquin Wolf (*Canis* sp.)

Demographic information

Demographic attribute	Value
Generation time. Based on average age of breeding adult: age at first breeding = X year; average life span = Y years.	3.5 years
Is there an observed, inferred, or projected continuing decline in number of mature individuals?	Possibly
Estimated percent of continuing decline in total number of mature individuals within 5 years or 2 generations.	Unknown
Observed, estimated, inferred, or suspected percent reduction or increase in total number of mature individuals over the last 10 years or 3 generations.	Unknown
Projected or suspected percent reduction or increase in total number of mature individuals over the next 10 years or 3 generations.	Unknown
Observed, estimated, inferred, or suspected percent reduction or increase in total number of mature individuals over any 10 years, or 3 generations, over a time period including both the past and the future.	Unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Unknown b. Yes c. Possibly
Are there extreme fluctuations in number of mature individuals?	No

Extent and occupancy information in Ontario

Extent and occupancy attributes	Value
Estimated extent of occurrence. *(Request value from MNRF or use http://geocat.kew.org/)*	79710km^2
Index of area of occupancy (IAO). *(Request value from MNRF or use http://geocat.kew.org/)*	>10,000 km^2
Is the total population severely fragmented? (i.e. is >50% of its total area of occupancy is in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?)	a. No b. No

Number of locations (*as defined by COSEWIC*).	Population exists mainly in eight sites (plus numerous townships around Algonquin Park) in Ontario
Number of NHIC Element Occurrences (*Request data from MNRF)*	Not available
Is there an observed, inferred, or projected continuing decline in extent of occurrence?	Unknown
Is there an observed, inferred, or projected continuing decline in index of area of occupancy?	Unknown
Is there an observed, inferred, or projected continuing decline in number of populations?	Unknown
Is there an observed, inferred, or projected continuing decline in number of locations?	Unknown
Is there an observed, inferred, or projected continuing decline in [area, extent and/or quality] of habitat?	Unknown but unlikely
Are there extreme fluctuations in number of populations?	Unknown but unlikely
Are there extreme fluctuations in number of locations?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of mature individuals in each sub-population or total population (if known)

Sub-population of 488 (likely higher) has a minimum of 160 (likely higher) mature individuals.

Qualitative analysis (population viability analysis conducted)

The most recent PVA suggests that the population will be stable in the near-future (Patterson and Murray, 2008).

Rescue effect

Rescue effect attribute	Likelihood
Is immigration of individuals and/or propagules between Ontario and outside populations known or possible?	Unknown but unlikely
Would immigrants be adapted to survive in Ontario?	Probably
Is there sufficient suitable habitat for immigrants in Ontario?	Possibly

Is the species of conservation concern in bordering jurisdictions?	Yes (Quebec)
Is rescue from outside populations reliant upon continued intensive recovery efforts?	No

Appendix 2: Adjoining jurisdiction status rank and decline

Information regarding the status rank and decline for the Algonquin wolf

Jurisdiction	Subnational rank	Population trend	Sources
Ontario	S4	Stable	Patterson and Murray (2008)
Quebec	SNR	n/a	n/a
Manitoba	Not present	n/a	n/a
Michigan	Not present	n/a	n/a
Minnesota	Not present	n/a	n/a
Nunavut	Not present	n/a	n/a
New York	Not present	n/a	n/a
Ohio	Not present	n/a	n/a
Pennsylvania	Not present	n/a	n/a
Wisconsin	Not present	n/a	n/a

Acronyms

APP: Algonquin Provincial Park
COSEWIC: Committee on the Status of Endangered Wildlife in Canada
COSSARO: Committee on the Status of Species at Risk in Ontario
DNA: Deoxyribonuleic acid
EOO: Extent of Occurrence
ESA: Endangered Species Act
GRANK: global conservation status assessments
IAO: index of area of occupancy
MHC: major-histocompatibility complex
MNRF: Ministry of Natural Resources and Forestry
NHIC: Natural Heritage Information Centre
PVA: population viability analysis
RAD: restricted-site associated DNA
SARA: Species at Risk Act
SNR: unranked
SRANK: subnational conservation status assessment
S4: Apparently Secure