Status of the eastern wolf (*Canis lycaon*).

By

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Taxonomic Designation.

There were two competing hypotheses related to the taxonomy of the eastern wolf. It is presently formally designated a sub-species of the gray wolf, *Canis lupus lycaon*. Recently it has been proposed, based on genetic data, that the eastern wolf is not a sub-species of the gray wolf but is closely related if not identical to the red wolf (*Canis rufus*). It has further been suggested it retain its original taxonomic designation of *C. lycaon* (Pocock, 1935; Miller, 1912; Wilson et al 2000,). The most definitive data demonstrating that the eastern wolf is not a sub-species of gray wolf is the analysis of two wolves from Maine and the Adirondacks in New York, that were killed prior to western coyote expansion at the end of the 19th century. Neither animal contained gray wolf mitochondrial DNA (Wilson et al in prep a). These data lead to the formal rejection of the hypothesis that the eastern wolf is a gray wolf sub-species. The mitochondrial data and the ready hybridisation of the red wolf and the eastern wolf with the western coyote, *C. latrans,* supports the suggestion that they are North American-evolved wolves closely related to the coyote (Wilson et al, 2000). This suggestion also explains the lack of hybridisation between sympatric western gray wolves and western coyotes.

The recognition of two distinct wolves in Ontario was made initially by Standfield (1970a, b) and the idea was developed by Kolenosky and Standfield (1975). Standfield (1970) states;

"The northern limit of the Algonquin-type appears to be close to the ecotone between the boreal and deciduous forest. This coincides closely with the limits of white-tailed deer in Ontario. The Ontario-type is chiefly confined to boreal forests. We do not recognise a cline between the Ontario and Algonquin types…In behaviour the two races also appear to differ. The Ontario type is primarily a predator on moose, with caribou and deer as supplementary prey. Pack size is usually larger than that of the Algonquin type. The latter preys primarily on deer and smaller mammals but seldom on moose, even when they are common, and pack sizes seldom approach that of the Ontario type…".

We interpret their observations as the Ontario-type being *C. lupus* and the Algonquin type being *C. lycaon*.

A broad area in central Ontario became known as "Canis soup" as the expansion of the coyote impacted the area. A recent genetic analysis of the eastern coyote has indicated it resulted from hybridisation of the western coyote and eastern wolf (Wilson et al in prep b). The range of the eastern coyote (*C. latrans x lycaon*)

extends throughout southern Ontario and Quebec and the Maritime Provinces and much of New York and the New England States. This large population harbours a considerable portion of the eastern wolf gene pool and this must be recognised in any conservation, re-introduction and management plans. This animal is larger than the western coyote and can readily hybridise with eastern wolves. This situation is causing difficulties for the red wolf re-introduction program. The US Fish and Wildlife Service is managing the problem by killing or sterilizing hybrids. We feel that this approach will not work as hybridisation is not the fundamental issue. The problem is the lack of suitable habitat, in the chosen re-introduction locations, which will select for a wolf over the hybrid. The hybrid presently out-competes the wolf in the human-altered patchy and fragmented habitat. We will note later that the appropriate experiment is being carried out naturally in and to the south of Algonquin Park. The genetic data here shows there is a barrier to gene flow from eastern coyotes to the Park wolves. This barrier is likely both a selection against hybrid progeny in the Park and the result of female wolves choosing large male wolves over smaller hybrid males. We have Y-chromosome data that supports this interpretation (Shami et al in prep).

Pre-Columbian habitat and range.

Both the red wolf and eastern wolf have long been recognised as small wolves that primarily prey on white-tailed deer (Forbes and Theberge, 1992,1995 and 1996). It is likely that the original range of the eastern wolf (*C. lycaon/rufus)* paralleled the southern broadleaf forest that stretched from the Great Lakes area and the St Lawrence River south to the Gulf Coast and east from the Mississippi river to the east coast (Fig 1). John Josselyn in 1672 recognised two kinds of wolves in eastern North America:

"The wolf, of which there are two kinds; one with a round ball'd foot. And are in shape like mongrel Mastiff's; the other with a flat foot, these are like greyhounds and are called deer Wolfs".
The closest relative of the deer wolf, the western coyote, adapted to the dry open areas while the wolves adapted to the forest ecotype (Fig 2). These wolves must have competed effectively with the Eurasian gray wolves (*C. lupus*) in this habitat as the latter were excluded from much of the eastern side of the continent, although it is likely there was some hybridisation at the boundary between the two species. The gray wolves occupied the north and western parts of North America primarily preying on caribou, moose, elk and bison (Fig 2). As Nowak (1983) noted the movement of the ice sheets during the late Pleistocene would have had a profound

effect on the distribution of wolves. The Pleistocene refugium for the eastern wolves was considered south of the ice sheets in eastern North America (Nowak 1983) which overlaps with the Pleistocene refugium for white-tailed deer (Cronin 1992). We have placed the original boundary between the two wolf species around the St Lawrence River in eastern Ontario as reports from the 1840s (DeKay 1842), from the Adirondacks, suggest the presence of two types of wolves in that region. It is likely the larger gray wolves in Canada were crossing the St Lawrence River and meeting *C. lycaon* in northern New York State. European settlement and its associated wolf control programs, de-forestation and farming set the stage for the recent widespread changes in the distribution of these three species.

Post-Columbian changes

It appears the range of the eastern wolf and red wolf was reduced to small regions of Texas, Minnesota, Manitoba, northwestern and central Ontario and Quebec (Fig 3). Although it is difficult to recreate the exact sequence of events it appears the eastern wolf extended its original range north in concert with the northern movement of its preferred prey, the white-tailed deer. The region that is now Algonquin Provincial Park was originally an elk, woodland caribou and moose dominated ecosystem with gray wolves as the top end predator. The intense logging sstarted in the mid-19th century eliminated the gray wolf, caribou and elk. The end of the 19th century would have witnessed the beginning of the colonisation of the Park by white-tailed deer followed by the small eastern wolf. This scenario would likely have been replayed in areas of Quebec. Pukaskwa National Park may be replaying a different version of events now as it apparently contains a few packs of gray wolves in a moose system (Grewal et al in prep a). Here there are signs of recent and low levels of introgession of eastern wolf genetic material into these resident gray wolf packs.

The eastern wolves of Minnesota, Manitoba and northwestern and northeastern Ontario and the northern range of Quebec are generally larger than those of central Ontario and southern Quebec. They have been previously described as hybridising wolves (*C. lupus x latrans*) (Lehman et al. 1991), although the new evolutionary model (Wilson et al. 2000) indicates they represent hybridisation between eastern wolves (*C. lycaon*) and gray wolves (*C. lupus*) at the boundary of the two species. Wolves in Manitoba contain both gray wolf mtDNA and a divergent *C. lycaon* mtDNA (Wilson et al. 2000). This extends the range of *C. lycaon* into the Upper Great Lakes region. There is evidence of this eastern wolf (*C. lycaon*) mtDNA in Isle Royale wolves (Lehman et al. 1991) that prey exclusively on moose and preliminary work on Minnesota wolves supports this. This situation was recognised

by Mech and Frenzel (1971), when they stated that the northeastern Minnesota timber wolves are assigned to *C. l. lycaon*, but they are from an area within 150 km of the range of *C. l nubilus* as described by Goldman (1944) and they questioned whether they are an intergrade between the two subspecies. They likely arose from limited hybridisation of *C. lycaon* with gray wolves at the boundary of the two species either historically as a result of Pleistocene ice movements or recently as a result of human disturbance.

The expansion of the western coyote at the beginning of the 20th century probably resulted in contact with residual pockets of eastern wolves in southern Ontario. There appears to have been a rapid expansion of numbers (Laviviere and Crete 1993) and the creation of the eastern coyote or Tweed wolf (*C. latrans* x *lycaon*) (Kolenosky and Standfield 1975, Wilson et al. in preb b), which is well adapted to the patchy forest and farmland of southern Ontario and Quebec. It now flourishes in the Maritimes and New York and New England States and represents the southern boundary of the eastern wolf in Ontario and Quebec. It demonstrates a large variation in size across its range from small animals in southwestern Ontario and large ones in the Frontenac Axis. It contributes significantly to the "Canis soup" in central Ontario.

Present Distribution.

Based on genetic profiles at microsatellite loci and mitochondrial DNA, animals can be classified and population distributions defined based on measures of gene flow (Grewal et al in prep). This classification established a conservative northern boundary for eastern wolves with gray wolves in Manitoba, Ontario and Quebec. The data are consistent with one continuous metapopulation of eastern wolves ranging from Manitoba to Quebec (Figs 3 and 4). In central Ontario and central Quebec the eastern wolves show the results of some hybridisation with coyotes (*C. lycaon* x *latrans*) and in the northern range they show the results of hybridisation with gray wolves (*C. lycaon* x *lupus*). The Algonquin Park wolves show limited gene flow with the Tweed wolves (*C. latrans* x *lycaon*) to the south (Grewal et al in prep b), but little differentiation with animals to the west and north. The present

range is far smaller than the original in North America (Fig 2) but significantly larger than the original range in Canada.

Abundance.

As an estimate of numbers we determined the area occupied by the eastern wolf based on the genetic criteria (Grewal et al in prep a) and used a density of 1 wolf/100 km^2 (Fig. 4 and Table 1). This gives a total population estimate of about 10,000 wolves with about 40% in Ontario and 20% in Quebec. The actual reported densities of eastern wolves vary from a high of 3.8 in Algonquin Park to about 0.8. As the eastern wolf (*C. lycaon* x *lupus*) is likely the only wolf-type in Minnesota, Wisconsin and Michigan we also present recent estimates of wolves in these areas as an indication of the accuracy of the estimates based on 1 wolf/100 km^2 (Table 1). These data suggest this density gives a conservative estimate and that the total number of eastern wolves is probably greater than 10,000. The wolves in Algonquin Provincial Park represent 2-3% of the total population.

Demographic trends

The data and anecdotal evidence suggest the range and numbers of the eastern wolf are increasing. Reports from native and non-native trappers are consistent with an increasing population and northerly expansion of the *C. lycaon* range with a corresponding decrease in gray wolf (*C. lupus*) range and numbers. The *C. lycaon* population in Minnesota has undergone a significant expansion, which prompted the USFWS to consider de-listing the gray wolf in the lower 48 states. These demographic changes may be further promoting hybridisation between *C. lycaon* and *C. lupus* and the selection of animals suited to the northern disturbed landscape.

Algonquin Provincial Park

The wolves in Algonquin Provincial Park have received considerable attention primarily as a result of long-term studies by Dr John Theberge. A number of issues have been raised including whether the Park animals are unique, whether they represent the purest form of the species, whether they represent an “island” population and whether they are under threat from "gene swamping" from eastern coyotes. Our interpretation of the genetic data to the above points are as follows: 1) The Algonquin Park wolves are not unique; 2) They are smaller than the northern

forms because they contain more coyote genetic material while the northern forms contain more gray wolf genetic material with animals to the west and north; 3) The Park is not an island with clear evidence of migrants and gene flow; 4) The park wolves are not at risk of gene swamping from eastern coyotes as long as the habitat is maintained. The present small wolf is apparently struggling in the changing Park ecosystem and therefore the eastern coyote is even more disadvantaged. It is likely that the coyote genetic material we see in Algonquin wolves resulted from the wolf culling in the Park in the 1950s when male wolves mated with female Tweed wolves. This is further supported by observations of local citizens of the presence of the first small wolves in the late 1950s (Louis Hodgson, pers. comm.). They attributed them to hybridisation experiments carried out by Pimlott and release of their progeny.

Recently the Algonquin Wolf Advisory Group (AWAG) made public some draft recommendations (AWAG, 2000). It is our position that the history and biology of the eastern wolf was not fully considered in the context of the changing Algonquin Park ecology. As stated previously the Park probably contained large ungulates and gray wolves prior to the logging of the 19th century. The eastern wolf and white-tailed deer then colonised the park starting at the end of the 19th century. Since the 1960s there has been a decline in deer and increase in moose and the ecosystem is now closer to that of the early part of the 19th century. Some wolves leave the park to follow the deer that over-winter outside the Park (Forbes and Theberge 1995, 1996) resulting in wolf mortality. The AWAG recommendations focus on these mortalities as well as managing the Park for deer as a way of preserving the small wolf. We do not agree with some of the recommendations as they do not follow an ecosystem approach. We feel more attention should be given to ensuring continued gene flow of the Park wolves with the packs in the north and west. This will minimise any detrimental effects of inbreeding and allow the evolution of the Algonquin wolves to a changing ecosystem, which is far preferable to managing the Park for deer and ill-adapted smaller animals (see below).

Summary

There is one connected metapopulation of *C. lycaon* that represents a cline of sizes that in part results from different levels of hybridization with the two other *Canis* species that do not hybridise with each other: the gray wolf (*C. lupus*) and the coyote (*C. latrans*). This metapopualtion contains the gene pool of *C. lycaon* and the introgressed genetic material of these other two species. As a result, this large connected metapopulation in Ontario, Quebec, Manitoba and the Upper Great Lake States maintains a high degree genetic variation and adaptive evolutionary potential.

The eastern coyote also contains a significant amount of the eastern wolf gene pool and between them they form the top predator in a range of ecotypes that have been disturbed by human activity. They are increasing in numbers and range while the gray wolf is decreasing in the face of human activity.

References

Algonquin Wolf Advisory Group (AWAG). The Wolves of Algonquin Provincial Park. A report to the Honourable John C. Snobelen, Minister of Natural Resources.

Cronin, M.A. 1992. Intraspecific variation in mitochondrial DNA of North American cervids. Journal of Mammalogy 73: 70-82.

DeKay, J.D. 1842. Natural History of New York. D. Appleton & Co. & Wiley Putnam.

Forbes, G.J. and J.B. Theberge. 1992. Importance of scavenging on moose by wolves in Algonquin Provincial Park, Ontario. Alces 28: 235-241.

Forbes, G.J., and Theberge, J.B. 1995. Influences of migratory deer herd on wolf movements and mortality in and near Algonquin Provincial Park, Ontario. *In* Ecology and conservation of wolves and a changing world. *Edited by* L. Carbyn, S. Fritts, and D. Seip. Canadian Wildlife Service. Edmonton, Alberta .

Forbes, G.J. and J.B. Theberge. 1996. Response by wolves to prey variation in central Ontario. Canadian Journal of Zoology 74:1511-1520.

Goldman E. A., 1944. Classification of wolves. *In* The wolves of North America. *Edited by* S.P. Young and E.A. Goldman. American Wildlife Institute, Washington, D.C. pp. 389-636.

Grewal, S.K., P.J. Wilson, A.D. Granacki, J.N. Heal, I. Lawford, T.L. Hillis, F.F. Mallory, H. Sears, M.T. Theberge, J.B. Theberge, D.R. Voigt, F. Burrows and B.N. White. Characterization of wolves across Ontario using mitochondrial and microsatellite DNA profiles. Submitted.

Grewal, S. K., P.J. Wilson, T. Kung, K. Shami, M.T. Theberge,J.B. Theberge and B.N. White. (In Prep.) A genetic assessment of the packs of the Eastern Canadian wolf, *Canis lycaon* in Algonquin Provincial Park and their relationship to surrounding populations

Kolenosky G.B. and R.O. Standfield. 1975. Morphological and ecological variation among gray wolves (*Canis lupus*) of Ontario, Canada *In* The Wild Canids. *Edited by* M.W. Fox. Van Nostrand Rienhold, New York. pp. 62-72.

Laviviere S. and M. Crete. 1993. The size of the eastern coyotes (*Canis latrans*). Journal of Mammalogy 74: 1072-1074.

Lehman, N., A. Eisenhauer, K. Hansen, D.L. Mech, R.O. Peterson, P.J.P. Gogan and R.K. Wayne. 1991. Introgression of coyote mitochondrial DNA into sympatric North American gray wolf populations. Evolution. 45: 104-119.

Mech, L.D., and L.D. Frenzel. 1971. The possible occurrence of the Great Plains wolf in northeastern Minnesota. *In* Ecological studies of the Timber Wolf in Northeastern Minnesota. *Edited by* L.D. Mech and L.D. Frenzel. U.S. Forest Service Research Paper NC-52. Northcentral Forest Experimental Station, St. Paul, Minnesota. Pp. 60-62.

Miller, G. S. 1912. The names of the large wolves of northern and western North America. Smithson. Misc. Coll. **59**:5 pp.

Nowak, R. M. 1983. A perspective on the taxonomy of wolves in North America. In Carbyn, L.N. ed. Wolves in Canada and Alaska. Can. Wildl. Serv. Rep. Ser. 45.

Nowak, R. M. 1995. Another look at wolf taxonomy. *In* Ecology and conservation of wolves in a changing world: proceedings of the second North American symposium of wolves. *Edited by* L. N. Carbyn, S. H. Fritts and D. R. Seip, Canadian Circumpolar Institute, University of Alberta, Edmonton, Canada. pp 375-398.

Pockock, R. L. 1935. The races of *Canis Lupus*. Proc. Zool. Soc. London, pt. 3, pp. 647-686.

Samson, C. 2000. Report on the status of the eastern wolf (Canis lupus lycaon) for the Committee on the Status of Endangered Wildlife in Canada. Request 1883-2C-septembre.

Shami, K., P.J. Wilson, S.K. Grewal, L. Noack and B.N. White. An analysis of the Y-chromosome in North American canid populations. In Preparation.

Standfield, R. 1970a, A History of the Timber Wolf (Canis lupus) Populations in Ontario, Canada. Appendix II Algonquin Park Museum.

Standfield, R. 1970b. Considerations on the taxonomy of wolves in Ontario. Proceedings of a Symposium on Wolf Management in Selected Areas of North America. United States Department of the Interior, Fish and Wildlife Service.

Wilson, P.J., S. Grewal, I. Lawford, J. Heal, A. Granacki, D. Pennock, J. Theberge, D. Voigt, B. Chambers, P.C. Paquet, G. Goulet, D. Cluff and B.N. White. DNA profiles of the eastern Canadian wolf and the red wolf provide evidence for a common evolutionary history idependent of the gray wolf. Canadian Journal of Zoology 78: 2156-2166.

Wilson, P.J., S. Grewal, T. McFadden, R.C. Chambers and B.N. White. Mitochondrial DNA extracted from eastern North American wolves killed in the 1800s is not of grey wolf origin. Submitted.

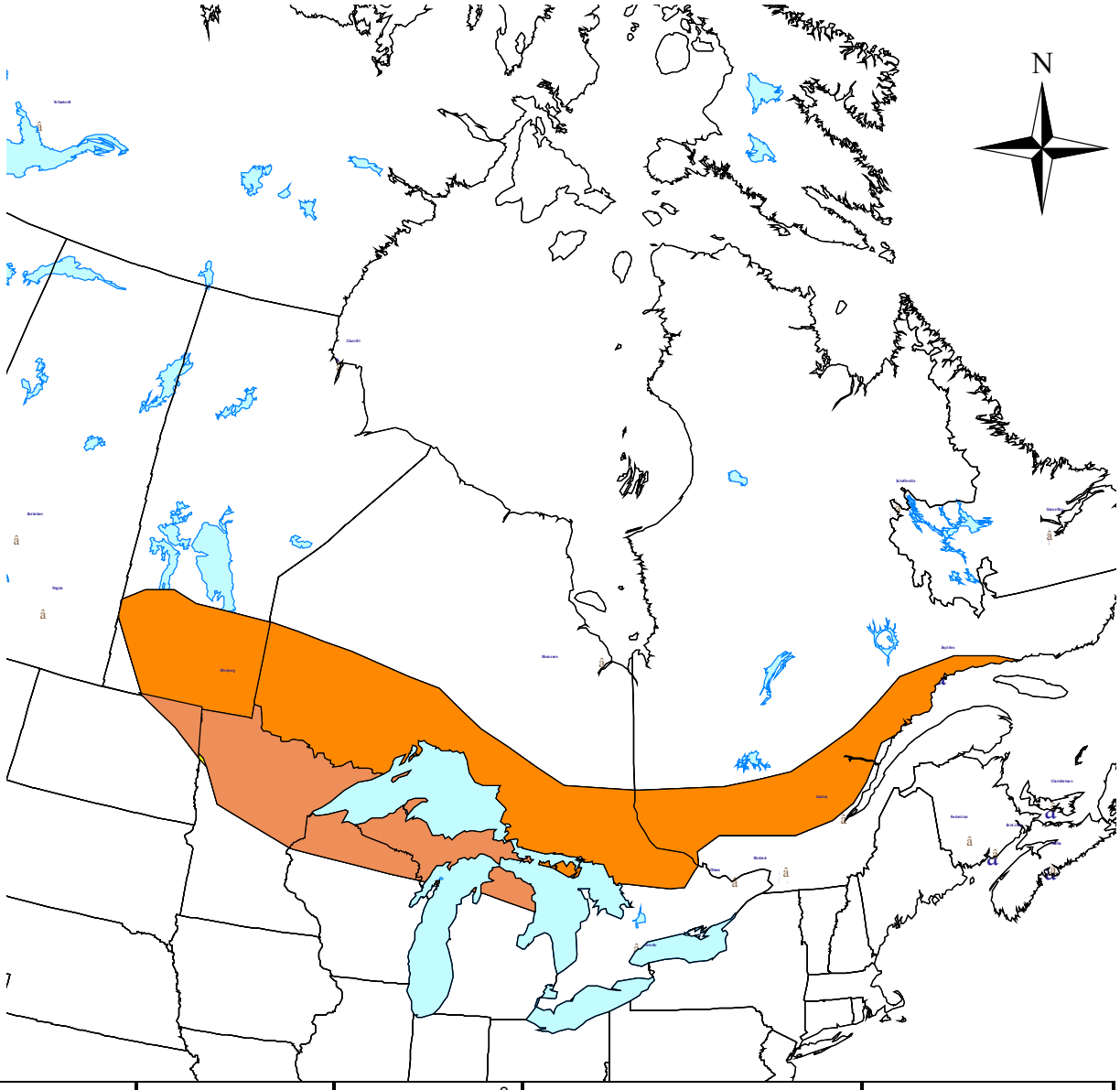
Wilson, P.J. S. Grewal, A. Granacki, K. Shami, R.C. Chambers, P. Paquet, J. Theberge, M. Theberge, B. Kelley, W. Waddell, M. Dumond and B.N. White. Genetic evidence for the origin of the eastern coyote by hybridisation between the western coyote and eastern timber wolf. Submitted.

Estimates of the eastern Canadian wolf *Canis lycaon* in North America.

State/Province	Area (Km^2)	#wolves (1/100 sq Km^2)	Actual estimates
Manitoba	**162,144**	**1621**	
North Dakota	3,275	33	
Minnesota	117,513	1175	3000?
Wisconsin	16,378	164	100?
Michigan	21,781	218	
Ontario	435,000	4350	
Algonquin Park	7,654	76	200
Quebec	114,306	1143	
TOTAL	**871,089**	**8924**	

Present day Range of Eastern Canadian Wolf.

March 6, 2001.



Location	Total # of Wolves	Total Area (Km^2)	Actual Estimate from Literature	Ref.
Manitoba	1554	155490		
North Dakota	140	14040		
Minnesota	1340	134050	2445	USFWS 2000
Wisconsin	416	41660	197	USFWS 2000
Michigan	641	64170	174	Mladenoff et al '99
Ontario	3769	376920		
Quebec	1970	197090		