IMPACT OF EVOLVING LAND USE PATTERNS ON WILDLIFE IN THE ADIRONDACK PARK
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Adirondack Park

INTRODUCTION

The Adirondack Park of New York State is a 24,300 km^2 (6 million acre) area, a unique mosaic of public and private lands supporting a mixture of wilderness and human-influenced landscapes. The Park was conceived by the New York State legislature in 1892 pursuant to concerns for timber and water resources, and in 1894 the Forest Preserve was granted the "forever wild" designation (Commission on the Adirondacks in the Twenty-First Century 1990). There have been only two changes to that designation, both of which required approval of a majority of state voters and two successive legislatures. These were in 1940 for the cutting of ski trails on Whiteface Mountain and again in 1958 for the construction of the Adirondack Northway. Any future designation changes seem highly unlikely. Within the Adirondack Park are lands owned publicly as well as private holdings. The public lands are classified as wilderness, primitive, canoe, wild forest and intensive use. The private land holdings consist of hamlet, moderate intensity, low intensity, rural use, industrial use, and resource management (Adirondack Park Agency Act & Amendments 1998). It is within the public lands that the conservation of biota is a primary management goal (Adirondack Park Agency Act & Amendments 1998), but increasingly private lands are coming under unrelenting developmental pressures. Exurban development, or that development characterized by low-density and large lot size (Glennon and Kretser 2005), is gaining popularity in the Adirondacks, as more individuals seek the beauty and solitude afforded by the mountains, lakes and forests. However, this exurban development causes severe ecosystem fragmentation, with its resultant negative impacts on the native flora and fauna (Saunders et al 1991;Glennon and Kretser 2005). The impact of growing developmental pressures

throughout the Adirondack Park, and the cumulative impact such evolving development might have on the wildlife diversity within the Park is the focus of this paper. We look at wildlife in general, and focus on potential reintroduction efforts of the eastern timber wolf, *Canis lupus lycaon*, (sic) in particular. The recent and controversial issue of the exact taxonomic designation of the eastern timber wolf as *Canis lupus lycaon*, a subspecies of the gray wolf, or as *Canis lycaon*, a separate species more closely related to the red wolf *Canis rufus* remains unresolved (Mech 1995; Paquet et al. 1999; Wilson et al. 2003). However designated, the eastern timber wolf is emblematic of the "forever wild" designation of this part of the Adirondacks, and the success of earlier reintroduction efforts for the species in the Rocky Mountain West lends a sound scientific base for considering a similar effort within viable Adirondack habitats (Haight et al. 1998; Mech 1995). Balancing biological and sociological considerations in any reintroduction effort requires delicate and deliberate actions across a wide range of interests (Mech 1995; Paquet et al. 1999; Wilson 2005).

BACKGROUND

The Adirondack Park, formerly the Forest Preserve, has been protected since 1892. Originally, protection focused on timber and watershed resources, and has expanded over the decades to include native biota, holistic ecological systems and the human-perceived quality of life (Commission on the Adirondacks in the Twenty-First Century 1990). As more individuals seek to escape the metropolitan areas, the developmental pressures on the Park continue to accelerate. In the early 1900s, recreational use of the Forest Preserve lands was basically unregulated, and few if any land-use regulations on private land were in place (Commission on the Adirondacks in the Twenty-First Century 1990). After a failed proposal to establish an Adirondack Mountain National Park, state stewardship of the region came to the political forefront. In 1968 then Governor Rockefeller appointed a study commission to develop guidelines for management of the Park; the resultant Adirondack Park Agency (APA) was established in 1971. In 1972 the APA adopted and the governor signed the State Land Master Plan, the blueprint for public use of the "forever wild" forest preserve. The Adirondack Park Land Use and Development Plan, which was adopted in 1973 after considerable public negotiations, covered use and development across the Park's privately held lands (Commission on the Adirondacks in the Twenty-First Century 1990). Of the 24,300 km^2 (6 million acres)

within the Blue Line, fully 52%, or 12,600 km^2 (3.1 million acres) are privately held (Adirondack Park Agency website 2007).

The earliest developments in the Park were within hamlets or along the existing highway corridors around the existing population centers (Glennon and Kretser 2005). Recently, however, exurban development has become the dominant residential land use form within the country, as well as the Adirondack Park (Glennon and Kretser 2005). While exurban development has been described as one of the primary causes of land and habitat loss, the phenomenon is not well studied (Glennon and Kretser 2005). Many of the referenced studies on exurban growth and its impacts to wildlife are correlated to studies of the effect of agricultural activities on the fragmentation of ecosystems (Glennon and Kretser 2005), and a majority of these studies have focused on ornithological populations. The major difference is that in exurban landscapes, the original ecosystem type remains largely intact. From a panoramic perspective, the original landscape appears relatively unscathed; however, from ground level, the once solid forest floor is interwoven with human-induced modifications. The natural biota of these previously unbroken landscapes notice the changes, and have species-specific responses to them (Saunders et al 1991; Glennon and Kretser 2005). Looking at the privately held lands, which account for 52% of the Park land holdings, fully 85% of those private lands are classified as "rural" or "resource management", upon which one single dwelling per 0.034 to 0.17 km^2 (8.5 to 42.7 acres) is a compatible use. This amounts to over 44% of all Park lands, as described in the Land Use Classifications and Acreage on the Adirondack Park Agency website (http://www.apa.state.ny.us). The use of these private lands and the continuing fragmentation of once intact ecosystems across these lands are two major issues with which the APA must increasingly contend (Glennon and Kretser 2005). An early interpretation of the impact of landscape fragmentation was given by the APA in the Butler Lake project (APA Project 89-312), in which the Agency restricted a permitted 30-lot subdivision on 305 acres of Low Intensity Use lands to 25 new residential buildings clustered away from Butler Lake, imposed a 200-foot "no-cut" zone within the lakeshore, prohibited the construction of boathouses or beaches along the lakeshore, and limited the land disturbance on each lot to 0.002 km^2 (½ acre). This project was never constructed, but the strictly-conditioned permit was believed to set the standard for future developments, specifically shoreline development (W. Kissel, 2007). Throughout the 1990's, and especially after the September 11, 2001 tragedies, the Park lands have

experienced unprecedented developmental pressures (Glennon and Kretser 2005; J. Anthony 2007). How then can this increasing fragmentation within the Park facilitate the preservation of the native flora and fauna, or even provide appropriate habitats for formerly extirpated species (e.g. eastern timber wolf)?

Canis lupus;Courtesy USFWS

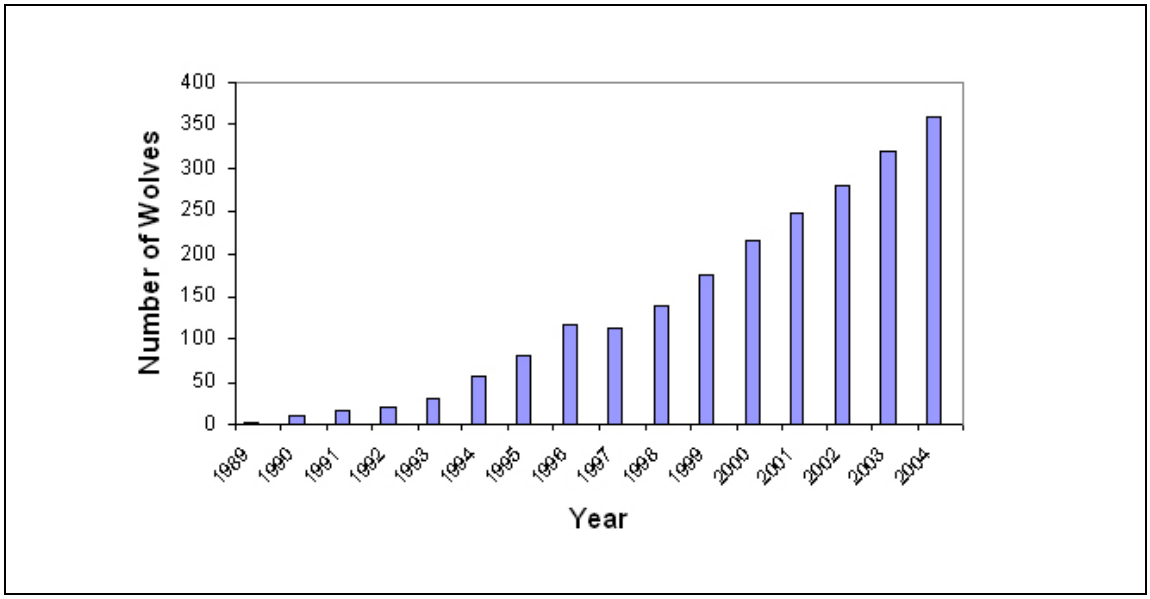
The eastern timber wolf, herein referred to as *Canis lupus lycaon* (sic), is one of the more intensively studied species as it relates to the human-wildlife interactions and impacts (Fuller 1989; Haight et al 1998; Mech 2000; Paquet et al 1999; Wilson 2005). Complete Federal protection under the Endangered Species Act (ESA) was afforded the gray wolf in 1973, and the species' Recovery Plan identified potential reintroduction areas in the upper Great Lakes regions of Minnesota, Michigan and Wisconsin (Mech 1995). By 1978 the United States Fish and Wildlife Service (USFWS) listed all species rather than subspecies. In 1992, the USFWS revised the recovery plan for *Canis lupus lycaon*, identifying the Adirondack Park as one of several areas for resettlement, along with the northern forests of Maine and New Hampshire (Inslerman 2001). As the Yellowstone gray wolf reintroduction initiative was being implemented in 1995, Nowak's revision of wolf taxonomy that same year modified the original 24 *Canis* subspecies into 5 (Nowak 1995). His revision identified the Minnesota wolf as the Great Plains wolf, *Canis lupus nubilis*, rather than *Canis lupus lycaon*. Inasmuch as the USFWS Eastern Timber Wolf Recovery Plan addressed the Great Plains wolf, the question of whether the government must recover *Canis lupus lycaon* also under the ESA remains unclear. Meanwhile, reintroduction studies inside the Adirondack Park were being conducted, resulting in the seminal report of "Wolf Reintroduction Feasibility in the Adirondack Park" by the Conservation Biology Institute in October 1999 (Paquet et al 1999). This report was one of the first to reference the recent use of genetic analysis employing mitochondrial DNA (mtDNA) and microsatellite DNA of various *Canis* species and subspecies, and which suggested "…the need for a revision of canid taxonomy in eastern North America"

(Paquet et al 1999). Dr. Paul Wilson of Trent University, Ontario, provided further scientific support for the controversial taxonomic reclassification (Wilson et al 2003), stating that "…the presence of the eastern timber wolf, *C. lycaon*, within Maine and New York in the 1880s has implications for reintroduction efforts in terms of which wolf species to move into these states. The genetic evidence supports the reintroduction of the eastern timber wolf, based on historical distribution." (Wilson et al 2003). This taxonomic investigation will continue in the northeastern US, while in the Western Great Lakes, that distinct population segment of the gray wolf was removed from the list of endangered and threatened wildlife on March 12, 2007, a celebrated success story for the Endangered Species Act (www.fws.gov/midwest/wolf/2007delisting/2007delist_fr.htm).

METHODOLOGY

Notwithstanding the uncertainity that currently exists with the proper classification of the historically native canid in the Adirondacks (Wilson et al 2003), the habitat requirements of *Canis* spp. are certainly known (Haight et al 1998; Mech 1995; Paquet et al 1999; Wilson 2005). The Isle Royale wolf population was founded in 1949 on the 538 km^2 island off of the Minnesota mainland by a dispersing pair. The population has persisted for over 55 years, with an average of 23 individuals (Mech 1995). Haight reports that many areas that have been recolonized by wolves are not wilderness, but are rather altered landscapes in proximity to human development (Haight et al 1998). He goes on to identify the Minnesota wolf landscape as one of "…a mosaic of forest, agricultural, and developed land under a variety of public and private ownerships" with mid-winter pack territories averaging 150-180 km^2 (Haight et al 1998). Other studies have suggested a 3000 km^2 pack territory as a minimum food-abundant, protected habitat size (Haight et al 1998). The analysis by Gurd and others of wildlife reserves, wherein wildlife conservation was a primary management objective, revealed that an expected minimum mammalian area requirement would be 5037 km^2 (Gurd et al 2001). They go on to observe that wolves have not persisted in reserves of less than 950 km^2 (Gurd et al 2001). Fuller conducted a six-year study of 5-8 wolf packs in northeast Minnesota in an area of 839 km^2. His study area was 66% public lands in an area where the timber wolf had not been extirpated. Over the six years of study, pack numbers ranged from three to eight; pack territories ranged from 51 to 197 km^2, with an average of 116 km^2; and number of wolves per pack averaged 6.7 (Fuller 1989). The density of wolves within the study area

ranged from 29 to 59 wolves/1000 km^2 seasonally. The mean annual rate of increase (λ) during 1980 to 1986 was 1.02, indicating a positive, albeit slow, population growth amid seasonal oscillations (Fuller 1989). Further, Fuller calculated a birth rate (b) of 0.37 wolves/year and an overall death rate of 0.35 wolves/year (Fuller 1989). In the state of Michigan, where wolves have dispersed successfully under ESA protection, populations continue to flourish as shown in the graph below (http://www.michigan.gov):



From the graph above, an annualized λ can be obtained (Gotelli 2001). The computed annualized value of λ from the above data set is 1.37. This value is somewhat higher than the one observed in Fuller's research (Fuller 1989), but not inconsistent with an exponentially growing population within a recently colonized habitat (Gotelli 2001). From the $\lambda_{(avg)}$=1.37, we can use Gotelli to calculate the intrinsic rate of increase: r=ln λ, or r=0.3148 wolves/wolvesxyear.

RESULTS

From the habitat area requirements, the field-observed rate of increase, and observed birth and death rates, we can make preliminary estimates of a potential wolf population within targeted Park lands (Gotelli 2001). The Park could provide a 10,525 km^2 area on wilderness and wild forest public lands, which are dispersed throughout the Park. The privately held resource management lands, which total another 6290 km^2, have the following as their statutory objective: "The basic purposes and objectives of resource management areas are to protect the delicate physical and biological resources, encourage

proper and economic management of forest, agricultural and recreational resources and preserve the open spaces that are essential and basic to the unique character of the park." (Adirondack Park Agency Act & Amendments 1998). One of the primary uses in resource management areas is "game preserves and private parks" (Adirondack Park Agency Act & Amendments 1998). Clearly within the public land holdings of wilderness and wild forest, combined with at least half of the privately held resource management holdings, an area of over 13,000 km^2 could be available for reintroduction efforts; this represents 50% of the total Park area. With a wolf density of 29 wolves/1000 km^2 (Fuller 1989), the previously identified public and private lands could hold 377 wolves. If we assume that only 25% of the available lands, or 3250 km^2, would be repopulated and that wolf packs would consist of 7 individuals at the same density of 29 wolves/1000 km^2, then almost 100 individuals or 13 packs could potentially be supported within the Park. Even at this 25% threshold, the overall wolf habitat area requirements are met (Fuller 1989; Haight et al 1998; Paquet 1999). Interestingly, when compared to the 950 km^2 area requirements of Gurd and others in their study of wildlife conservation reserves, only three or four packs could be supported, with a potential population of less than 30 individuals. The distinction between the Fuller (Fuller 1989) and Gurd (Gurd et al 2001) area requirements may be the fact that the Fuller study focused on an existing wolf population in Minnesota within an established habitat and with a history of human-wildlife interaction patterns (Fuller 1989). The Gurd study was a quantitative assessment of existing wildlife reserves areas and the mammalian species richness inherent within that reserve's size. A site specific or species specific assessment of each reserve was not part of this study (Gurd et al 2001), which may lend a more appropriate application of the Fuller study to the Adirondack situation. Using the Fuller birth and death rates (Fuller 1989) of b=0.37 ind/year and d=0.35 ind/year, we can project the probability of extinction of an introduced experimental population of wolves into the Park . Using the formula $P_{(ext)}=(d/b)^{No}$ (Gotelli 2001), with a varying founding population, we can assess the minimum number of individuals required to theoretically support a viable population:

N_o	$P_{(ext)}$
4	80%
8	64%
12	51%
13	49%

From this it can be shown that any founding population of at least 13 members would provide a greater than 50% chance of survival, assuming the cited birth and death rates. Further, with a founding population of 13 wolves (N_o=13), we can calculate the projected population in future years from $N_t=N_oe^{rt}$ (Gotelli 2001). For the 10^{th} year after reintroduction, a population growing exponentially, as was seen in the Michigan population, would be 303 individuals, well within the projected carrying capacity of the Park (Fuller 1989). Haight and others used the Fuller field observations for model simulation of a disjunct wolf population living in a large, semi-wild landscape with abundant, well-dispersed prey (Haight et al 1998). His model population consisted of 16 packs covering 4000 km^2 with varying number of core sites, varying immigration rates, different mortality rates, and either small or large initial populations (N_o). Model validation of mortality rates was conducted using a 24-individual hypothetical population and comparing model results with Fuller's field measurements (Haight et al 1998). The model simulations of Haight and others concluded that survival of disjunct wolf populations is favored and that long-term mortality and immigration are the dominant predictors of long-term survival (Haight et al 1998).

The biotic components supplementary to these assumptions are that an ample prey population is available and that human-caused mortality is not excessive (Haight et al 1998; Inslerman 2001; Mech 1995, 2001; Paquet 1999). The *Canis* spp. have a varied diet consisting primarily of white-tailed deer (*Odocoileus virginianus*), beaver (*Castor canadensis*), and snowshoe hare (*Lepus americanus*). Fuller evaluated wolf scat collections and found that in addition to the above prey species, Minnesota wolves consumed woodchuck (*Marmota monax*), red squirrel (*Tamiasciurus hudsonicus*), black bear (Ursus amerianus), chipmunk (*Tamias striatus*), as well as seasonal raspberries (*Rubus* spp.) and blueberries (*Vaccinium* spp.) (Fuller 1989). Given that white-tailed deer (*Odocoileus virginianus*) would constitute the primary prey for Adirondack wolves, estimates of consumption rates are given by Fuller as 18.8 deer/wolf/year and Mech as 15 deer/wolf/year (Fuller 1989; Mech 1995). Paquet and others have indicated that deer density of 1.0 deer/km^2 is adequate for wolf predation, and have stated that "…populations of white-tailed deer and beaver appear more than adequate to sustain wolves" (Paquet et al 1999).

The one universal biotic requirement necessary for wolf survival is that of human acceptance or at least tolerance (Fuller 1989; Haight et al 1998; Inslerman 2001; Mech

1995, 2001; Paquet et al 1999). Volumes have been written on the tortured history of wolves not only in New York State, but worldwide. It is well beyond the scope of this paper to dissect those works, but any wolf reintroduction program will of necessity be lengthy, controversial, and emotional (Smith and Ferguson 2005). The one in the Adirondacks has begun that arduous process (Mech 2001), while simultaneously confronting the taxonomic questions and the evolving land use patterns within the Park (Anthony 2007; Paquet et al 1999; Wilson 2003).

DISCUSSION

The 24,300 km^2 Adirondack Park is the largest protected temperate forest remaining in the northern hemisphere. As such, it is home to approximately 120,000 year-round residents and over 10 million visitors annually (Adirondack Park Agency website 2007), who collectively treasure the "forever wild" beauty that has defined the region since its protection was established in 1894. With so many individuals pressuring the resources of this vast area, only the land use and development plan standards established by the APA in 1973 have the ability to set the matrix of landscapes possible within the 52% of privately held Park lands (Adirondack Park Agency website 2007). But it is the interpretation of some of those land use standards and definitions that herald changing, fragmented landscape patterns (Anthony 2007). The accelerating pressure of exurban development within the Park (Glennon and Kretser 2005) brings with it the fragmentation of once whole habitats and the resultant negative impacts to native biota and prospective reintroduction species. A prime example is the eastern timber wolf (*Canis lycaon*).

As discussed by Crandall and others, conservation biologists classify populations as evolutionarily significant units (ESUs) based on ecological and genetic data (Crandall et al 2000). Supplemental to this would be the increasing reliance on molecular phylogenies (Crandall et al 2000). In the case of the eastern timber wolf (*Canis lycaon*), the molecular phylogenies have been determined by Wilson and others (Wilson et al 2003) and show that rather than a subspecies, *Canis lupus lycaon*, the eastern timber wolf is a separate species worthy of conservation efforts. Using the ESU adaptive distinctiveness categories of population exchangeability (genetic and ecological) through time (recent and historical) (Crandall et al 2000), the following matrix is obtained, recommending treatment of *Canis lupus* and *Canis lycaon* as distinct species:

+	+
+	-

Given the scientific validation that the two species are distinct (Crandall et al 2000; Wilson et al 2003), the theoretical and field verification that a reintroduced wolf population of at least 13 individuals has a greater than 50% chance of survival within a 3250 km^2 area (Fuller 1989; Haight et al 1998), and the availability of adequate prey for the reintroduced population (Paquet et al 1999), the science supports a reintroduction program in the Adirondacks. However, the growing fragmentation of private lands within the Park will continue, as exurban developments march across the Park landscape. The Adirondack Park Agency is currently reviewing what is seen as a precedent-setting land use project, the Adirondack Club and Resort, a 25.1 km^2 (6200 acre) residential community surrounding the Big Tupper Ski Area (APA project 2005-100). The project is precedent-setting in that it will clarify the secondary use of privately-held resource management areas, specifically the provision "…resource management areas will allow for residential development on substantial acreages or in small clusters on carefully selected and well designed sites." (Section 805(2) of the APA Act). The interpretation of "substantial acreages" will forever determine the fate of some of the largest private holdings within the Park (Anthony 2007). APA Project 2005-100 intends to carve out 23 Great Camp lots, in addition to 70 single family residential units, with the allowable building density of one residential unit/0.17 km^2 (42.7 acres). The Great Camp lots will be 0.28 to 0.40 km^2 (70 to 100 acres) in size, and existing logging roads will serve 21 of the 23 proposed lots, thus minimizing additional land disturbance for roadways. Within these Great Camp parcels, the buildable portion will be limited to 0.02 km^2 (5 acres), with professionally managed forests throughout the remaining Great Camp lands (Anthony 2007). In addition, across the 25.1 km^2 project area, over 5.0 km^2 will be directed into a permanent conservation area, a requirement reflective of the growing concern of the APA for "habitat impact" ramifications of such projects (Anthony 2007). While APA Project 2005-100 has the benefit of an environmentally conscientious sponsor and group of consultants on a 25.1 km^2 parcel which historically had been logged extensively, future smaller projects in resource management zones may not see the same level of sponsor/consultant commitment (Anthony 2007). Easily, permitting for such large complex projects take several years with costs in the hundreds of thousands of dollars (Anthony 2007; personal observations). Future Adirondack projects will follow the

environmental constraints imposed upon APA Project 2005-100, but the end result will still be the continuation of ecosystem fragmentations.

It is with this realization that exurban development will continue within the Park (Anthony 2007; Glennon and Kretser 2005), and will result in more frequent human/wildlife interactions and conflicts, that this researcher concludes that a wolf reintroduction program within the wilderness, wild forest and parts of the resource management lands of the Park is not validated. The documented wolf success repopulations (Fuller 1989; Haight et al 1998; Mech 2001) and the calculated Adirondack wolf populations contained herein, all point to a successful reintroduction program. It can be shown that with a minimal founding population of 13 wolves in the Park, that within 10 years, the carrying capacity of the Park as it exists in 2007 would be reached. The one environmental stochastic variable influencing that projection has to be the continuing exurban land development within the Park and the increasing human/wildlife interactions and conflicts such development would bring. In lieu of a free-ranging *Canis lycaon* population within the Park boundaries, perhaps a "resource management" protected wildlife reserve, similar to the Wolf Conservation Center in South Salem, Westchester County, New York (http://www.nywolf.org) would be prudent. The land usage would comply with APA compatible uses, and the center would provide an educational venue as well as the potential for captive breeding programs for the definitive Adirondack canid. While reserves are not palatable for the strict conservation biologist, one in the Adirondacks might serve for education and species propagation, and might eventually permit the emblematic timber wolf to reclaim the "forever wild" Adirondack Park in concert with the Park's human inhabitants.

BIBLIOGRAPHY

Adirondack Park Agency Act and Amendments. 1998. http://www.apa.state.ny.us.

Adirondack Park Agency website. 2007. http://www.apa.state.ny.us.

Anthony, S.J. 2007. Principal of The LA Group, a landscape architectural consulting firm in Saratoga Springs, New York. Personal communications.

Commission on the Adirondacks in the Twenty-First Century. 1990. The Adirondack Park in the 21st Century. Technical Reports: Volume I and II. Albany, N.Y.

Crandall, K.A., O.R.P. Bininda-Emonds, G.M. Mace, R.K. Wayne. 2000. Considering evolutionary processes in conservation biology. TREE 15(7): 290-295.

Fuller, T.K. 1989. Population Dynamics of Wolves in North-Central Minnesota. Wildlife Monographs: No. 105.

Glennon, M. and H. Kretser. 2005. Impacts to Wildlife from Low Density, Exurban Development: Information and Considerations for the Adirondack Park. Wildlife Conservation Society – Adirondack Communities & Conservation Program; Technical Paper #3.

Gotelli, N.J. 2001. A Primer of Ecology. Sinauer Associates, Inc. pp.2-47.

Gurd, D.B., T.D. Nudds, D.H. Rivard. 2001. Conservation of Mammals in Eastern North American Wildlife Reserves: How Small is Too Small? Conservation Biology 15(5): 1355-1363.

Haight, R.G., D.J. Mladenoff, A.P. Wydeven. 1998. Modeling Disjunct Gray Wolf Populations in Semi-Wild Landscapes. Conservation Biology 12(4): 879-888.

Inslerman, R.A. 2001. Wolf Restoration in the Adirondacks: The Perspective of the New York State Department of Environmental Conservation in Wolves and Human Communities: Biology, Politics and Ethics. V.A. Sharpe, B. Norton, and S. Donnelley, editors. pp 23-31.

Kissel, W.H. 2007. Former APA Board member. Personal communications.

Mech, L.D. 1995. The Challenge and Opportunity of Recovering Wolf Populations. Conservation Biology 9(2): 270-278.

Mech, L.D. 2001. Wolf Restoration to the Adirondacks: The Advantages and Disadvantages of Public Participation in the Decision-Making Process in Wolves and Human Communities: Biology, Politics and Ethics. V.A. Sharpe, B. Norton, and S. Donnelley, editors. pp13-22.

Paquet, P.C., J.R. Strittholt, N.L. Staus. 1999. Wolf Reintroduction Feasibility in the Adirondack Park. Conservation Biology Institute; Corvallis, Oregon.

Saunders, D.A., R.J. Hobbs, C.R. Margules. 1991. Biological Consequences of Ecosystem Fragmentation: A Review. Conservation Biology 5(1): 18-32.

Smith, D.W. and G. Gerguson. 2005. Decade of the Wolf: Returning the Wild to Yellowstone. The Lyons Press. 211pp.

United States Fish & Wildlife Service. 2007. http://www.fws.gov.

Wilson, P.J., S. Grewal, ID. Lawford, J.N. Heal, A.G. Granacki, D. Pennock, J.B. Theberge, M.T. Theberge, D.R. Voigt, W. Waddell, R.E. Chambers, P.C. Paquet, G. Goulet, D. Cluff, B.N. White. 2000. DNA profiles of the eastern Canadian wolf and red wolf provide evidence for a common evolutionary history independent of the gray wolf. Can. J. Zool. 78:2156-2166.

Wilson, P.J., S. Grewal, T. McFadden, R.C. Chambers, and B.N. White. 2003. Mitochondrial DNA extracted from eastern North American wolves killed in the 1800s is not of gray wolf origin. Can. J. Zool. 81: 936-940.