

**Coyote (*Canis latrans*) Colonization of New York:
The Influence of Human-Induced Landscape Changes**

by

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Abstract

The coyote (*Canis latrans*) was historically restricted to the prairie ecosystems of the midwest United States. In less than two centuries, however, coyotes have succeeded in colonizing most of North America, from the Pacific Ocean to the Atlantic, north into Alaska and south into Panama. Several hypotheses exist to explain this phenomenon. An empty niche created by the extirpation of the gray wolf, human modification of the landscape, increases in prey abundance and availability, and the translocation and releases of individual animals, are all thought to have facilitated this rapid and dramatic range extension. This study examines these theories in one particular area of relatively recent coyote establishment, New York State. Although these hypotheses are inextricably linked, particular attention is paid to the relationship between human-induced habitat alterations and coyote movements over time. A detailed collection and examination of first occurrence reports throughout the state over the last century was conducted. GIS analysis of this data resulted in a particular direction and pattern of coyote colonization previously undocumented. Historic trends in farmland abandonment and reforestation in the last 100 years were similarly mapped. Results indicate a strong correlation and significant statistical relationship between anthropogenic land use changes, and coyote range extension through New York State.

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Introduction

The coyote (*Canis latrans*) is one of the most successful and widely distributed mammalian predators found in the western hemisphere today (Bekoff & Wells, 1986; Knowlton et al. 1999). The coyote's range expansion throughout North America in the last two centuries is unparalleled by any other mammal species in recent history. Traditionally restricted to the open grasslands and prairie ecosystems of the midwest United States, today the coyote is commonly found throughout the US, Canada and Mexico, its range stretching as far north as the Arctic Circle and as far south as Panama (Bekoff, 1978; Parker, 1995; Gompper, 2001a).

Several hypotheses are commonly cited to help explain this broad and rapid range extension. The extirpation of the coyote's primary competitor, the gray wolf (*Canis lupus*), throughout most of its former range in the 19th century is thought to have created an empty ecological niche ripe for exploitation (Mech, 1970; Parker, 1995; Peterson, 1996). Extensive modification of the landscape through deforestation and agricultural development as human settlers moved west, in conjunction with increases in coyote prey densities and availability, likewise helped expand the coyote's range (Gompper, 2001a). The importation and release of coyotes into areas where they were previously nonexistent, could also potentially have aided in their establishment in particular areas (Parker, 1995).

Coyote colonization of the northeastern portion of North America is a relatively recent phenomenon. Sporadic reports of coyote-like canids in northern New England, New York, and the southeastern Canadian provinces of Ontario and

Quebec began in the early 1900's (Hilton, 1978; Moore & Parker, 1992; Parker, 1995; Gompper, 2001a). Through the 1930's and 1940's these reports became more frequent, and by the 1980's the coyote was firmly established and widespread throughout the Northeast (Parker, 1995). What helped facilitate this? Why did coyotes show up in the Northeast when they did? And how did these animals move through and establish themselves in the northeast in such a relatively short period of time?

This thesis attempts to answer these questions by focusing on coyote expansion in one particular region, New York state. A closer examination of the hypotheses briefly outlined above, with particular attention paid to the relationship between habitat changes and coyote colonization, was conducted. While these theories are not necessarily exclusive, this study attempts to test the hypothesis that human-induced landscape changes were the most influential factor in coyote colonization patterns in New York State, and thus in the Northeast in general.

Background

A detailed, full-scale historical and landscape-level analysis of coyote colonization in New York State has never been attempted. The best published information available are two excellent articles, one authored by A.W. Bromely in 1956, and another written by C.W. Severinghaus, a former New York Conservation Commission (now known as the Department of Conservation) big game biologist in the mid 1970's. Each article, in particular Severinghaus's (1974), outlines the history of wild canids in New York, including a description of the extent of occupied coyote

range. The actual pattern of colonization and direction in which New York's coyote range extended in the last century, is less understood.

Some believe that coyotes were native to New York, and have always been present here in low numbers (Tullar, 1992). Although fossil evidence from the archeological record suggests that *Canis latrans* might have existed in the Northeast during the Pleistocene Era (Gipson, 1978; Nowak, 1978; Gompper, 2001a), it is generally accepted that coyotes were absent from the state before showing up in northern New York in the 1930's and 1940's (Severinghaus 1974; Parker, 1995). From there, they moved in a southward and northeastern direction, becoming common and firmly established throughout the state by the 1980's. In 1999, a coyote even found her way into the heart of New York City, namely Central Park (Gompper, 2001a), and today coyotes are frequently found in people's backyards, driveways (Batchellor, pers. comm.), or even denning in the median of a busy highway (Brown, pers. comm.).

Wolves

The most widely accepted theory for the absence of coyotes east of the Great Plains prior to the 1900's, is that gray wolves were present and therefore excluded coyotes (Young & Jackson, 1951; Pringle, 1960; Mech, 1970; Kolenosky & Stanfield, 1975; Harrison, 1986; Litvaitis, 1992). Although these two species can and sometimes do interbreed (Silver & Silver, 1969; Mengel, 1971; Hilton, 1978; Nowak, 1978; Schmitz & Kolenosky, 1985; Lehman et al. 1991; Chambers, 2000; Wilson et al., unpublished) and have co-occurred in the western part of their range, wolves and

coyotes are not generally tolerant of one another. Wolves have been known to kill coyotes (Young & Goldman, 1944; Stenlund, 1955; Berg & Chesness, 1978; Carbyn, 1982), and many studies have been conducted showing that coyote and wolf territories do not, for the most part, overlap (Berg & Chesness, 1978; Fuller & Keith, 1981; Paquet, 1991; Arjo & Pletscher, 1999). Where they do coexist, coyote densities tend to be reduced (Carbyn, 1982; Schmitz & Kolenosky, 1987; Paquet, 1989; Arjo, 1998).

The last documented report of a wolf in New York was in 1897 (Seagers, 1948). Bounties were paid on six wolves in St. Lawrence and Franklin counties in 1895, 1896, and 1897 (Anonymous, 1947a; Franklin County Records Center). A final specimen from St. Lawrence County was offered for payment in 1899, but was never verified as a true wolf (Anonymous, 1948). Regardless, *C. lupus* was extirpated from the state by the end of the 19th century. Clearly wolf numbers in New York decreased due to direct human persecution, but reductions in their prey species due to both human-induced habitat alterations and extensive hunting may also have led to their extinction in the state.

As European settlers began colonizing the Northeast, the forest began to rapidly disappear (Cronon, 1983; Williams, 1989). Vast areas of land were cleared and stripped of trees for use in the fuel, timber and tanning industries (Considine, 1984; Whitney, 1994). By the late 1800's, much of New York's mature forests had been logged, such that only 25% of the state's total land area was forest cover, most of which occurred in small, isolated fragments (Stanton & Bills, 1996).

Wolves are adapted to cooperative group hunting and prey primarily on large ungulates such as moose (*Alces alces*), caribou (*Rangifer tarandus*), elk (*Cervus elaphus*) and white-tailed deer (*Odocoileus virginianus*) (Mech, 1970; Fox, 1975; Pimlott, 1975; Gittleman, 1986). As a result of one hundred years of severe deforestation and consistent hunting pressure, the wolf's larger prey species gradually disappeared from New York (with the exception of white-tailed deer). The last documented report of an elk killed in the state, for example, dates to 1844 in Alleghany County, and the last moose to 1861 in the Adirondacks (Seagers, 1948).

Land Use in New York

Most of New York's land had been cleared, tilled, and pastured by 1900, at which time concern over the denuded landscape and the "timber shortage" began to grow (Bullock, 1920; Keller, 1980; Terrie, 1994; Knott, 1998). In sharp contrast to the widespread deforestation of the 18th and 19th centuries, the 20th century was characterized by a strong emphasis on reforestation and land protection.

In 1901 the state instituted an extensive Reforestation Program aimed primarily at replanting and rehabilitating Forest Preserve Lands in the Adirondacks and Catskills (Bullock, 1920; Cook, 1974). Nurseries were established throughout the state, and large-scale forest tree seedling production was begun. By 1908, trees were distributed for the first time to private landowners, predominantly farmers, such that only one year later over one million trees had been raised and distributed for planting (Guise, 1919; Eliason, 1959; Conklin, 1964). A relatively even balance was maintained between state and private planting until 1920, when there was a rapid

increase in the activity of private owners, and the total amount of trees planted on private land far outnumbered those planted on public land (Littlefield, 1953). Simultaneous to this success was a sharp and consistent decline in New York's farmland.

In the last 100 years in New York, hundreds of thousands of hectares of farmland have reverted to forests. Up until the late 1800's, land throughout the state was still cleared for farming, and actual numbers of farms and farmland continued increasing until approximately 1880 (Stanton & Bills, 1996). The following thirty to forty years of Census of Agriculture records illustrate neither an overall increase nor decrease in farmland. By 1920 however, many small "on-the-hill" farms (farms in areas with particularly poor soils) were unable to survive the Great Depression, and subsequently abandoned their land. In the 1920's alone, the total number of abandoned agricultural land reached almost 1,200,000 hectares statewide.

In direct reaction to these losses, the State passed a constitutional amendment in 1929 known as the Enlarged Reforestation Program specifically designed to acquire and actively reforest 400,000 hectares of submarginal farmlands over a fifteen year period (Fosburgh, 1947; Littlefield, 1953; Cook, 1974; Stanton & Bills, 1996). Additional farmland loss however, continued through the 1930's and, coupled with the general economic depression of the era, increased in severity. By 1950, over two million hectares of farmland had been abandoned, popularly referred to as "1/6 of the state" (Fosburgh, 1947).

By the 1950's, mechanical power had begun replacing horsepower, and other technological advances in the agriculture industry, made it possible to increase

total agricultural output with substantially less land and human effort (Bills & Stanton, 1996). As a result, farmland continued to be abandoned at a fairly rapid rate until approximately 1970. In the last thirty years, total land in farms per county has continued declining, albeit at a slower pace, such that today almost 3,000,000 hectares of farmland have been abandoned since the turn of the 20th century. While nearly 75% of New York's land area in 1900 consisted of farmland, and only 25% of forest, today it averages less than 25% total agricultural land area, and almost 62% forest cover. (Alerich & Drake, 1995; Stanton & Bills, 1996) (Figure 1, Figure 2; adapted from Stanton & Bills, 1996). Much of the abandoned farmland was either acquired and replanted by the state through vigorous reforestation programs, or left to regenerate naturally.

Coyote Foraging Ecology

Coyotes are opportunistic and generalist feeders (Ozoga & Harger 1966; Gier, 1975; Gipson and Sealander, 1976; Bekoff 1977; Todd & Keith 1983; Reichel, 1991). They have been known to eat "anything they can chew" (Parker, 1995), but are most often regarded as predators of rodents and lagomorphs (Hilton, 1978; Bowen, 1981; MacCracken & Hansen, 1987). In some areas they also feed extensively on ungulates (Hamlin et al., 1984; Messier et al., 1986; Andelt et al., 1987; Dibello et al., 1990; Lavigne, 1992; Gese & Groth, 1995). They are highly adaptable carnivores whose diets vary both between habitats, and in response to seasonal food availability (Van Vuren & Thompson, 1982; Harrison & Harrison,

1984; Parker 1986; Andelt et al., 1987; MacCracken & Hansen, 1987; Dibello et al. 1990; Brundige, 1993).

When coyotes began expanding into New York in the 1940's, the landscape consisted of predominantly fragmented, early succession woodlots and abandoned fields. This patchy, mixed-growth habitat consisted of open areas interspersed with young coniferous and deciduous tree stands, and provided an ideal environment for small mammals, rodents, and white-tailed deer (Chambers et al., 1974; Harrison, 1986; Kendrott, 1998). Populations of woodchucks (*Marmota monax*), cottontail rabbits (*Sylvilagus floridanus*), snowshoe hare (*Lepus americanus*), several rodent species (*Microtus spp.*) and white-tailed deer thrived in these surroundings (Severinghaus & Brown, 1956; Goff, 1979; Bittner & Rongstad, 1982), and subsequently provided an abundant prey base for newly colonizing coyotes.

Methodology

To better establish the coyote colonization pattern and direction of their range extension in New York on both a spatial and temporal scale, I researched and collected first occurrence reports and documented sightings dating back to the year 1900. Because coyotes were such a rarity, and because they were, more often than not, considered a highly undesirable newcomer, I believe these reports give an accurate depiction of both their presence and absence in particular areas, and their movement across the state.

I began by examining popular county level newspapers, as well as the entire run of regional outdoor magazines and scientific journals such as *Adirondack Life*, the *New York State Conservationist*, *New York Fish and Game Journal*, and *Fur, Fish & Game*. I also researched museum archives, namely the American Museum of Natural History, and the State Museum at Albany, for records of early coyote specimens.

Several phone surveys were also conducted. A total of twelve field stations throughout the eastern portion of the state (where coyotes first began establishing themselves) were contacted (Table 1). Additionally, County Clerk's offices of each county in eastern New York were surveyed in an attempt to locate old bounty records or bounty laws from the late 1800's and early 1900's.

Interviews were also conducted, formal and informal, with current and retired state biologists, wildlife technicians, professors, game wardens, professional trappers, hunters, taxidermists, fur buyers, and farmers throughout eastern New York State. I chose my interviewees based primarily on age and expertise, such that I tried to interview people who were approximately 60 years old or older, or those who were present during the early stages of coyote colonization.

From this data, a series of maps was created using ArcView / GIS mapping software. Reports were subdivided by county for every decade over the last 100 years. Distinctions were made between reports of coyotes that included actual carcasses (i.e. bounty records, reports with a photograph, reports that were verified by a state biologist or museum mammalogist at the time), reports that did not include a carcass (sightings or reports of coyote howls), and coyote harvest records (which

exist from 1979 onwards). One legend (Figure 3) was generated for all coyote colonization maps (Figures 4-13). When available, individual records were marked in the point of origin on the map (i.e. a town, game refuge, etc.). If locations were not available, records were marked either in the center of the county, or in the general vicinity of reports with a known location (based on both documented reports and interviews conducted).

To illustrate land use changes in New York in the last century, primarily farmland abandonment, I researched the Historical Census Data Browser, Inter-University Consortium for Political & Social Research (<http://fisher.lib.virginia.edu>) and the United States Department of Agriculture's New York Agricultural Statistics Service (<http://www.nass.usda.gov>). Information on forest cover and protected areas was obtained primarily from a study conducted by the Department of Agricultural, Resource, and Managerial Economics of Cornell University (Bills & Stanton, 1996), the Department of Conservation, Division of Lands and Forests, the United States Geological Service's National Land Cover Data Set, and interviews conducted with members of the New York Quality Communities Taskforce Agency, the Forest Service's Northeast Experiment Station, and New York State Parks and Recreation Division. This data was also mapped on a county level.

Results and Observations

Coyote Colonization Patterns

"Charles Gower, who is the inspector of the high tension electric wired, was up on a 35 foot pole testing the lines when his attention was suddenly attracted by the howling of wolves which were running from the woods. Luckily he had his testing

set with him on the pole, and he called the Geneva [Conservation Department] office and requested that help be sent out to him immediately."

"The first coyote or prairie wolf ever known to have been seen in Tompkins County was killed a few days ago by Phil Lewis of Spencer, who today sent the pelt to an Ithaca sporting goods store where it is on exhibition."

"A large male wolf has been captured by Lute Trim on Duane Mountain within 15 miles of Malone. The animal measured nearly five feet from tip to tip."

These authentic reports to the Conservation Commission all date back to the year 1920. And every one of them is false. In the first instance, upon closer investigation Mr. Gower admitted that his report had simply been a hoax. The coyote that was apparently drawing quite a crowd to the store where its pelt was being displayed in Tompkins County, turned out to be a German Shepard and, it was later confessed, had been an advertising ploy by a local practical joker. And finally, the skin of the wolf that had supposedly been shot in Malone, while indeed did belong to a timber wolf, had in fact been mailed to Mr. Trim (Anonymous, 1920). A few other reports of supposed coyotes, coydogs, brush wolves, prairie wolves, new wolves or Adirondack wolves, terms used interchangeably to refer to *Canis latrans*, also exist during this time period. All these reports, however, were similarly discredited by Conservation Department officials or museum scientists who routinely investigated them (Chambers, 1977).

The earliest documented report of a potentially true coyote (described as a wolf) in New York State is 1906 (Figure 4) (Tullar, 1992). A few other early reports of verified coyotes occurred in particular areas of western and southern New York in the early 1900's and 1920's (Figure 5, Figure 6). These animals were described as imported and released western coyotes (Streever, 1936, 1953; Pringle, 1960;

Severinghaus, 1974). Tourists brought back coyote pups with them from the west as prospective pets, for example, and the coyote was also considered a popular mascot on military reservations and navy shipyards (Young & Jackson, 1951; Chambers, 1977). The number of released or escaped individuals during this time period, although not definitively known, was not large enough to establish viable, long-lasting, or ecologically significant populations of coyotes (Parker, 1995). Most of these animals were reported killed a few days or a few months later, and were absent from the western and southern New York landscape for at least another 20 to 30 years (Figures 7 - 11). These incidents were frequent enough, however, to merit the passing of a bill in the late 1920's forbidding the importation or harboring of coyotes, coydogs, or wolves without notifying and obtaining permission from the Conservation Department beforehand (Tullar, 1992).

Despite this, additional reports of released coyotes occurred in the mid 1930's in Franklin County, and in selected areas of the Capitol Region (Figure 7). In fact I believe it is highly likely that some of the earliest museum specimens dating back to this period (Albany State Museum Records, American Museum of Natural History Collection), are the same animals that were liberated in Saratoga County. The only potentially authentic report of a naturally colonizing coyote occurred in Franklin County in 1925, just 15 miles south of the Canadian border in the town of Belmont (Severinghaus, 1974; Tullar, 1992). Coyotes had begun establishing themselves in southeast Ontario in the early 1920's (Hilton, 1978), but the earliest documented report of a coyote in southwest Quebec did not occur until 1944 (Young & Jackson, 1951). It is highly probable then, that this particular animal was an

escaped or released captive as well, although this cannot be established definitively. Regardless of their origin, the coyotes reported in Franklin County in the 1930's apparently did not persist (Severinghaus, 1974), and coyotes were not reported again in that county until the mid 1940's (Figure 8).

During these same years several areas of New York State harbored small, localized populations of feral dogs (Chambers et al., 1974). These feral dogs existed in the state throughout the 20th century, but were of particular concern in the 1920's, 30's and 40's. Hundreds of wild canids were being trapped or shot each year throughout this time period (Severinghaus, pers. comm.), reflecting a relatively high density of feral dogs. This, despite a strict dog licensing law, as well as a law forbidding owners to allow their pet to run free outside of any city or village limits (Anonymous, 1947b). These regulations were enforced primarily to help protect the state's deer herds, as it was believed that the "homeless predatory dogs" were causing considerable damage to deer and livestock alike (Anonymous, 1947b; Petruska, 1949). One report claims that feral dogs were responsible for the deaths of 1,000-1,500 deer in the Catskill region alone, following a severe and prolonged winter in 1947 (Anonymous, 1948). In 1949, the New York State Commissioner established a Special Dog Committee, composed of representatives of the Departments of Agriculture, Health and Conservation, as well as the Association of Town Officials, to discuss a solution to the 'dog problem' (Petruska, 1949). This is simply to say that feral dogs existed in robust numbers throughout the state during the early stages of coyote colonization. Coyote-dog hybrids, however, were only reported in very particular areas of the state.

Beginning in the early 1940's, coyotes and reported coydogs began appearing with increasing frequency in several of the counties bordering Canada, and in particular St. Lawrence and Lewis counties (Chase, 1949-50; Severinghaus, 1974)(Fig. 8). A rather extensive though relatively short-lived coydog population occupied the northwest corner of Adirondack Park, primarily establishing itself along the periphery (Bromley, 1956; Severinghaus, 1974)(Figure 14). Material evidence for this coydog population does not exist today, even though these individuals were systematically hunted and trapped throughout the 1940's. Over 100 coydog pelts and skulls were collected and freezer-stored at the New York State Delmar DEC Office (Severinghaus, pers. comm.). These particular animals were distinguished from the hundreds of feral domestics that simultaneously inhabited the area, because of their decidedly coyote-like characteristics. Other younger specimens of patchy fur coloration (red, brown, white and black patches) were identified as coydogs either because the mother of the litter, when caught, was positively identified as a coyote or, if the mother was not captured, was often seen and described by professional trappers as a shy, "wild" creature with predominantly gray fur. Unfortunately, the 100 plus coydog specimens that were being stored in Delmar, were discarded and sold at the Schoharie fur market before they could be thoroughly examined, and no pictures were ever taken (Severinghaus, pers. comm.).

To reiterate, these coydogs were most often reported and trapped along the northwestern edge of the Adirondacks. Documentation of "true" coyotes, on the other hand, tended to be focused in areas along the Ontario/New York border (Chase, 1949-50; Dailey, 1952). These two facts corroborate the theory (Parker, 1995) that coyotes

began colonizing New York from Ontario by crossing the St. Lawrence River sometime in the very early 1940's, possibly even the late 1930's.

Research had also been conducted in the 1930's and 40's concerning the possibility that coyotes might have entered the state from Pennsylvania (Severinghaus, pers. comm.). However, Conservation Department officials and wildlife biologists from several different regional offices in the Lake Erie area, were convinced that the animals had not yet extended their range along the southern side of the Great Lakes. The first documented report of a coyote in Pennsylvania does not occur until the late 1950's (Parker, 1995), and coyotes are not reported in far western New York until the 1970's (Fig. 11).

By the mid 1940's it was apparent that coyotes had increased their range from St. Lawrence and Lewis counties into neighboring counties, and that the coydog population had decreased considerably throughout the region (Chambers, 1977). (Coydogs did continue to be trapped into the 1960's and 1970's in other areas of the state, including the Adirondacks, but their numbers were fairly thin and scattered.) Reports of coyote sightings gradually increased (Figure 8), and by 1946 several counties began coyote bounties (Table 2) (Chase & Westervelt, 1950-51). Most of the earlier bounties were paid in St. Lawrence, Lewis and Franklin counties, while Warren, Washington, and Hamilton counties didn't pay off any bounties until 1948-49. The number of individual coyotes bountied in each county is indicative of the presence of the animal in the respective county. However, the actual quantities may be suspect and most likely do not reflect coyote distributions, as neighboring counties often paid different dollar amounts for each pelt (i.e. St. Lawrence county paid \$50

per pelt, while Lewis only paid \$25 per pelt). Often times trappers would travel the extra distance from the county they had originally caught the coyote in, to another county with a higher bounty (Gebo, pers. comm.). It was also not required to tag pelts or mark them in any way until a few years after the bounty system was established, and there were instances where the same pelt was counted and paid for more than once (Thorpe, pers. comm.).

Coyotes had begun to establish themselves in the very northern portion of New York by the mid to late 1940's, such that by 1949, the state government intervened by establishing a Coyote Control Program. This program, while it did include the trapping or 'control' of coyotes, was designed primarily to investigate and collect definitive information about the range, habits and influences of this new predator (Chase, 1949-50). Within a year, it had been confirmed that the coyotes' occupied range existed primarily between the Ontario-St. Lawrence- New York border and the periphery of the Adirondacks, with "an average penetration of 50 miles inland from the Ontario-St. Lawrence shore lines" (Chase, 1949-50). It was also determined that smaller but similar zones of occupancy existed in the northeastern and southeastern Adirondacks, as was corroborated by the bounty records (Figure 8). Population levels, however, on the whole seemed to remain relatively stable throughout this period. Even in areas where coyotes had been established for several years, such as in St. Lawrence County, there was no indication that population densities had increased significantly (Chase, 1949-50).

At this time there were also a few records of coyotes in the central Adirondacks (Figure 8). These reports, however, are extremely scarce; I could find

only two. Hence, while some coyotes might have ventured into the central Adirondacks in the 1940's, they primarily existed along the northern edge of the Adirondacks with smaller, more sparse pockets of colonization along its southeastern periphery in Warren and Washington counties (Bromely, 1956). Even though coyotes were present, they did not succeed in penetrating into the heavily forested region of the central Adirondacks in appreciable numbers until the mid to late 1950's and early 1960's, and even then remained at fairly low densities (Arndt, pers. comm.). According to historic track count records in Huntington Forest (Sage, pers. comm.) and deer starvation surveys throughout the Adirondacks (Severinghaus, pers. comm.), coyotes were still a relatively rare occurrence during this time period.

In fact dead deer surveys conducted up through the late 1950's were still possible because carcasses actually existed. By the mid 1960's however, most deer carcasses were heavily scavenged, and winter deer starvation surveys became futile and obsolete (Severinghaus, pers. comm.). It was also in 1950 that the Finch & Pryne paper and pulp company hired their first coyote control trapper in the central Adirondacks. Throughout the 1950's and 60's, numbers of coyotes trapped were limited to 1 or 2 per year in the Newcomb area of the Central Adirondacks (Arndt, pers. comm.), however by 1970 roughly 15 were being trapped annually.

By the early 1950's coyotes had also begun appearing in Rensselaer and Columbia counties along the Vermont / Massachusetts / New York border (Figure 9). The first reported coyote den site just north of Schenectady, was investigated in the mid 1950's (Severinghaus, pers. comm.) And just a few years later coyotes were reported with increasing frequency in the Catskill region. Coyotes were entering

these areas in an east-northeasterly direction (Figs. 9,14). In all likelihood, the coyote range in the northern Adirondacks was extending east into Vermont from Clinton and Essex counties. From the northeastern portion of New York and the northwestern corner of Vermont, coyotes then moved south along Lake Champlain, and began colonizing the upper reaches of the Mohawk-Hudson Lowland region.

In the mid 1960's, coyotes became increasingly common in the upper Hudson Valley and Catskill region, and by the early 1970's had penetrated into areas as far west as Cayuga County, and as far south as Putnam County (Severinghaus, 1974; Chambers et al., 1974)(Figure 11). In 1971, the bounty system was outlawed, and in 1976, the coyote became a protected game species, for which open and closed hunting and trapping seasons were established (DEC, 1991). Harvest records subsequently became available from 1979 onwards. Today the coyote inhabits most regions in the state, excluding Long Island and New York City (Figure 13), and is even found in heavily populated and developed areas such as the Bronx (Fahrenthold, 1995; Gompper, 2001a). Although few studies exist examining coyote densities in the northeast (Samson & Crete, 1997; Parker, 1995; Gompper, 2001a), total numbers of coyotes in New York State are roughly estimated at 20-30,000 individuals statewide (Department of Environmental Conservation, 2001).

Farmland Conversion & Coyote Range Extension

Knowing the spatial and temporal thrust of coyote range extension through New York, one can examine the relationship between farmland abandonment and the early stages of coyote colonization. Presence or absence of coyotes per county, and

cumulative farmland lost per county since 1920 (when farmland abandonment became significant) was compared. A map illustrating coyote reports from the initial stages of colonization, namely the 1940's, and cumulative farmland loss from 1920 to 1950, is shown in Figure 15. A second map depicting coyote range extension into south-central New York during the 1950's, and cumulative farmland loss from 1920 to 1960, is shown in Figure 16.

In the 1940's, coyotes are present in those counties with the highest amount of abandoned agricultural land (Fig. 15). Coyotes are most frequently located along the outer edge of the Adirondacks as they moved south into Lewis County and east into Vermont. This is unsurprising, as the Adirondack ecosystem consists of predominantly mature forest stands. Coyote localities were most concentrated between the timber country of the Central Adirondacks, and the extensive farming belt just north of the Park. While a statistical analysis showed there was no significant difference between farmland loss in the northern counties with or without coyotes (1-tail t-test with unequal variance; $p = .24$), this is probably due to small sample size. Counties chosen included those with coyotes present, and those that neighbored counties with reported coyotes (Clinton, Essex, Franklin, Fulton, Hamilton, Herkimer, Jefferson, Lewis, Oneida, Saratoga, St. Lawrence, Warren, and Washington). Only four counties exhibited minimal farmland loss, and two of them, or 50%, reported coyotes. Coyotes did not establish themselves in the mature forests of the central Adirondack ecosystem in significant numbers at this time (Figs. 14, 16). Rather, areas with substantially higher amounts of coyotes are closely associated with those counties with the highest amounts of farmland conversion.

Coyotes extended their range from these northern counties into the farm and forest region of the New York/Vermont border, and south through the farm country of western Vermont, into New York in areas just south and southeast of the Adirondacks (Figure 16). T-test analysis (single-tail of unequal variance) of cumulative farmland loss and coyote presence / absence in the 1950's in the southern counties (Albany, Columbia, Delaware, Dutchess, Fulton, Greene, Herkimer, Montgomery, Orange, Otsego, Putnam, Rensselaer, Saratoga, Schenectady, Schoharie, Sullivan, Ulster, and Washington) does exhibit a significant relationship ($p = .04$). Coyotes did not continue moving along the edge of the park, but instead began establishing themselves in areas with high amounts of abandoned agricultural land (Fig. 16). While the majority of the counties in the Mohawk-Hudson Lowland region had lost substantial amounts of agricultural land by this time, coyotes were most often found in counties with the highest amounts of farmland conversion.

Additionally, when examining the overall pattern of coyote colonization (Fig. 14) and the pattern of farm acreage lost (Figs. 15, 16), a relationship appears to exist between the loop shape of early range extension and the loop shape of agricultural land lost per county since 1920. These results indicate a significant relationship between areas of high farmland conversion, and historic coyote presence or absence.

Another possibility that might explain this pattern is human population. A t-test analyses was run (single tail of unequal variance) testing the relationship between human density per county, and coyote presence / absence per county. No significant correlation was found for the northern counties ($p = .12$), or the southern

counties ($p = .43$). For example, there were more people per square kilometer in Lewis County (7) than in Hamilton County (<1) in the 1940's, but coyote presence was highest in Lewis County. Conversely, Washington County had an average of 22 people per square kilometer, and coyotes were present there, but again, not in counties with either less (Herkimer County had a human population of 17 people per square kilometer), or more people (Saratoga County averaged 36 people per square kilometer). Human density might have played a significant role in Oneida County (70 people per square kilometer), where coyotes are not documented in appreciable numbers until the 1960's, even though farmland abandonment was relatively high. This, however, requires further analysis.

Discussion

This study shows that coyotes began establishing themselves in the northwest portion of New York state in the early 1940's (Fig. 8). After entering New York from Ontario over the St. Lawrence River, coyotes extended their range east into Vermont, remaining along the periphery of Adirondack State Park. From there, coyotes moved south along the New York/Vermont border and west back into New York state into areas of the Capitol Region by the early 1950's (Fig. 13). Coyotes did not show up in the Adirondacks in appreciable numbers until the late 1950's. During the 1960's, coyotes were reported with increasing frequency in the Catskill region (Fig. 10), and by the early 1970's had moved as far west as Cayuga County (Fig. 11). In the 1980's coyotes were commonly found throughout the state (Fig. 12), excluding New York City and Long Island. This particular pattern of coyote colonization in

New York strongly correlates with historic trends in the abandonment and reforestation of agricultural lands throughout the state. During the early stages of colonization, coyotes are most often present in areas with high amounts of farmland conversion, or fragmented landscapes of predominantly early succession growth, as opposed to heavily forested areas.

Contrary to the belief that *C. latrans* was always present in the central Adirondacks in low densities (Tullar, 1992), data collected here indicate that coyotes crossed into New York from Canada over the St. Lawrence River (Fig. 8). Although some believe that coyotes began colonizing New York as early as the 1920's or 1930's (Parker, 1995), animals trapped during this time period were most likely released and imported western coyotes. This is evidenced by the fact that coyotes remained absent from areas in which they were initially encountered for several decades (Figs. 5-9). This study also finds virtually no evidence in support of the theory that the extirpation of the gray wolf played a pivotal role in coyote range expansion. While the extermination of *C. lupus* did coincide with the appearance of the coyote, it was not the primary determinant in the successful establishment of coyotes in New York.

While this study does show a strong relationship between farmland conversion and coyote colonization patterns, it is an analysis based strictly on correlations. Several other variables might dictate a similar pattern. Changes in prey densities, for example, might have heavily influenced coyote movements over time. Although it is known that white-tailed deer densities were very low in the northern counties during the early stages of coyote colonization, and especially along the periphery of the Adirondacks, where coyote densities were highest (Brundige, 1993;

Severinghaus, pers. comm.), fluctuations in other prey species may also have played an important role. Thus while this research does exhibit a significant correlation between coyote presence and abandoned farmland, further analysis of other potential causes is recommended. Likewise, while abandoned farmland seems to have played a critical role in coyote colonization in the northeast, other regions of North America could have different processes at work that might have created a similarly patchy, fragmented landscape.

It is generally believed that coyotes prefer agricultural lands interspersed with brush areas and woodlots, or second and third growth forest fragments as opposed to heavily forested areas (Ontario Ministry of Natural Resources, 1974; Coppinger et al., 1975; Andelt & Gipson, 1979; Goff, 1979; Kendrott, 1998). Post (1975), for example, in a study conducted in the Tug Hill region of New York, reported a significant avoidance by coyotes of dense, closed-canopy forest plantations in the area. Samson and Crete (1997) found very low population densities in the boreal forests of southeast Quebec, and suggested that mature, heavily forested ecosystems represent marginal habitat for coyotes. Tremblay et al. (1998) compared summer foraging strategies of forest-dwelling and rural coyotes in southeast Quebec. Results showed that coyotes inhabiting rural landscapes had smaller home ranges and higher quality diets, also implying that forest landscapes are suboptimal habitat. Todd (1985), likewise found that farmland coyotes had higher fat indexes and a more stable demography as compared to coyotes in forested areas. This preference for rural landscapes has also been shown to vary seasonally (Todd, 1985; Parker & Maxwell, 1986; Person & Hirth, 1991).

A few studies on the foraging ecology of coyotes have been conducted in New York. The first, conducted from 1956-1961 in the Adirondack area (Hamilton, 1974), showed snowshoe hare to be the primary food item year-round, with white-tailed deer and red squirrel (*Tamiasciurus hudsonicus*) varying in importance according to season. Chambers (1986) conducted a similar study in the same area almost twenty years later (1975-1977) and found white-tailed deer and snowshoe hare to be the principal prey species consumed. Brundige (1993) likewise found white-tailed deer to be the coyote's primary food item in the late 1980's, beaver (*Castor canadensis*) and snowshoe hare also constituting a large portion of overall food consumed. Scat samples collected in the summer and fall seasons of each of these studies also showed a relatively high percentage occurrence of fruit, primarily raspberry (*Rubus spp.*) and blueberry (*Rubus spp.*), and a variety of insects. Additional research conducted in central New York in the 1970's indicate a preference for insects, fruit, and several small mammal species, predominantly woodchuck and rabbit (Chambers, 2000). Other food studies of eastern coyotes reflect a similar diet (Ozoga & Harger, 1966; Chesness & Bremicker, 1974; Hilton, 1976; Harrison & Harrison, 1984; Lapierre, 1985; Messier et al., 1986; Moore & Miller, 1986; Person, 1988; Parker & Maxwell, 1989; Patterson, 1995; Samson & Crete, 1997).

Many of the above prey species are typically associated with young, second growth forest or open areas, and tend to occur at higher densities in more disturbed habitat. This includes white-tailed deer (Severinghaus & Brown, 1956; Behrand et al., 1970; Henshaw, 1982), snowshoe hare (Brocke, 1975; Bittner &

Rongstad, 1982; Litvaitis et al., 1985), cottontail rabbit (Boyd, 1991; Peitz et al., 1997), woodchuck (Henderson & Gilbert, 1978; Swihart & Picone, 1991, 1995), blueberries and raspberries (Post, 1975; Goff, 1979; Toweill & Anthony, 1988; Kendrott, 1998). Large tracts of mature forests, on the other hand, tend to support fewer potential coyote prey species (Goff, 1979; Andelt et al., 1987; Toweill & Anthony, 1988;).

Habitat selection by coyotes is heavily influenced by prey availability (Ozoga & Harger, 1966; Hilton, 1978; Litvaitis & Shaw, 1980; Andelt & Andelt, 1981). Clearly the coyote is a highly adaptable predator who can readily alternate food sources as they become available. However, because the vast majority of species consumed are heavily associated with patchy habitat and early succession growth as opposed to contiguous climax forests, areas such as abandoned fields and younger tree stands simply represent more favorable coyote habitat. Hence these species, their abundance and availability in agricultural areas as compared to older, more forested areas, may very well influence coyote movements. Although additional examinations of coyote ecology in agricultural as opposed to heavily forested regions of New York is recommended before any definitive conclusions between prey availability and habitat selection can be drawn, the results of this study indicate that farmland conversion was indeed the major factor influencing how coyotes colonized New York.

Understanding how human land use practices affect coyote movement or establishment in particular areas could help minimize potential conflict with humans. Coyotes commonly inhabit rural landscapes or areas with low human densities, but

more recently they are also found in heavily developed and populated urban and suburban areas throughout North America (Andelt & Mahan, 1980; Bekoff & Wells, 1982; MacCracken, 1982; Shargo, 1988; Atkinson & Shackleton, 1991; McClure et al., 1995; Quinn, 1995, 1997; Bounds & Shaw, 1997; Baker & Timm, 1998; Gompper, 2001b). Interactions between coyotes and humans in New York are also becoming more frequent (DEC, 2000; Batcheller, pers. comm.). As forest stands throughout the state continue to age, especially in Forest Preserve lands such as the Adirondacks and the Catskills, coyote densities may very well decrease in these areas. As a result, *C. latrans* might favor predominantly disturbed landscapes with younger forests and, as is often the case, more people. Ultimately, by gaining a more thorough understanding of how anthropogenic habitat alterations, both historic and current, influence coyote movements, we can make better, more informed and finally more effective, management decisions.

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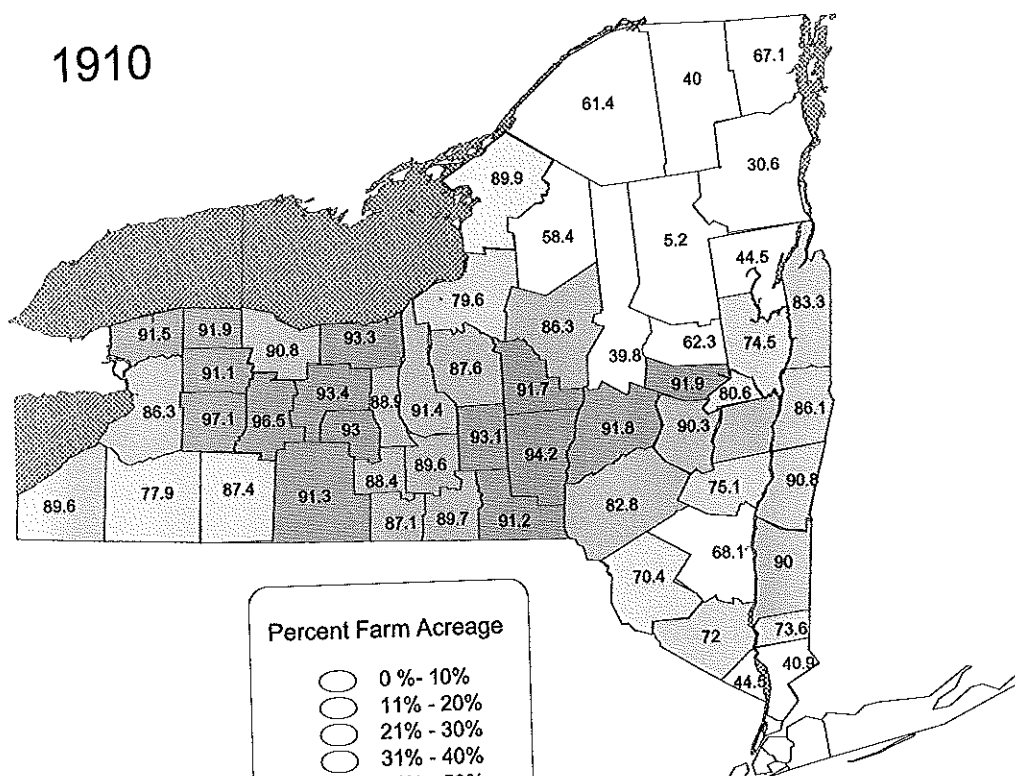
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Appendix

Total Percent Farmland Per County 1910 As Compared to 1992

1910



1992

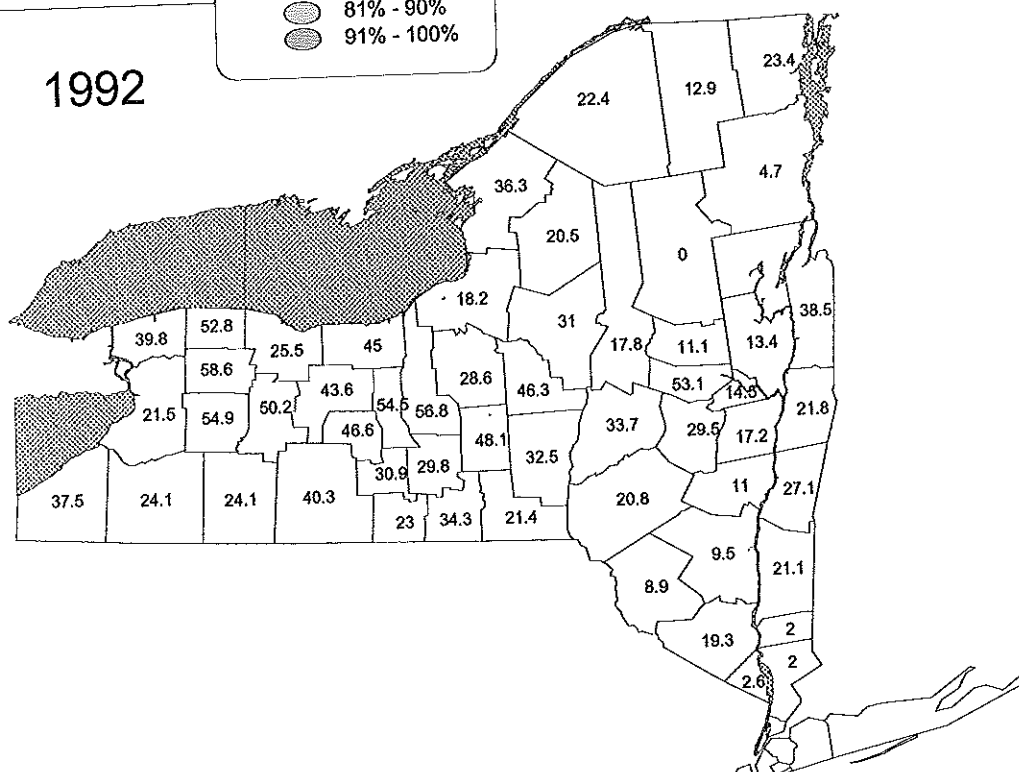
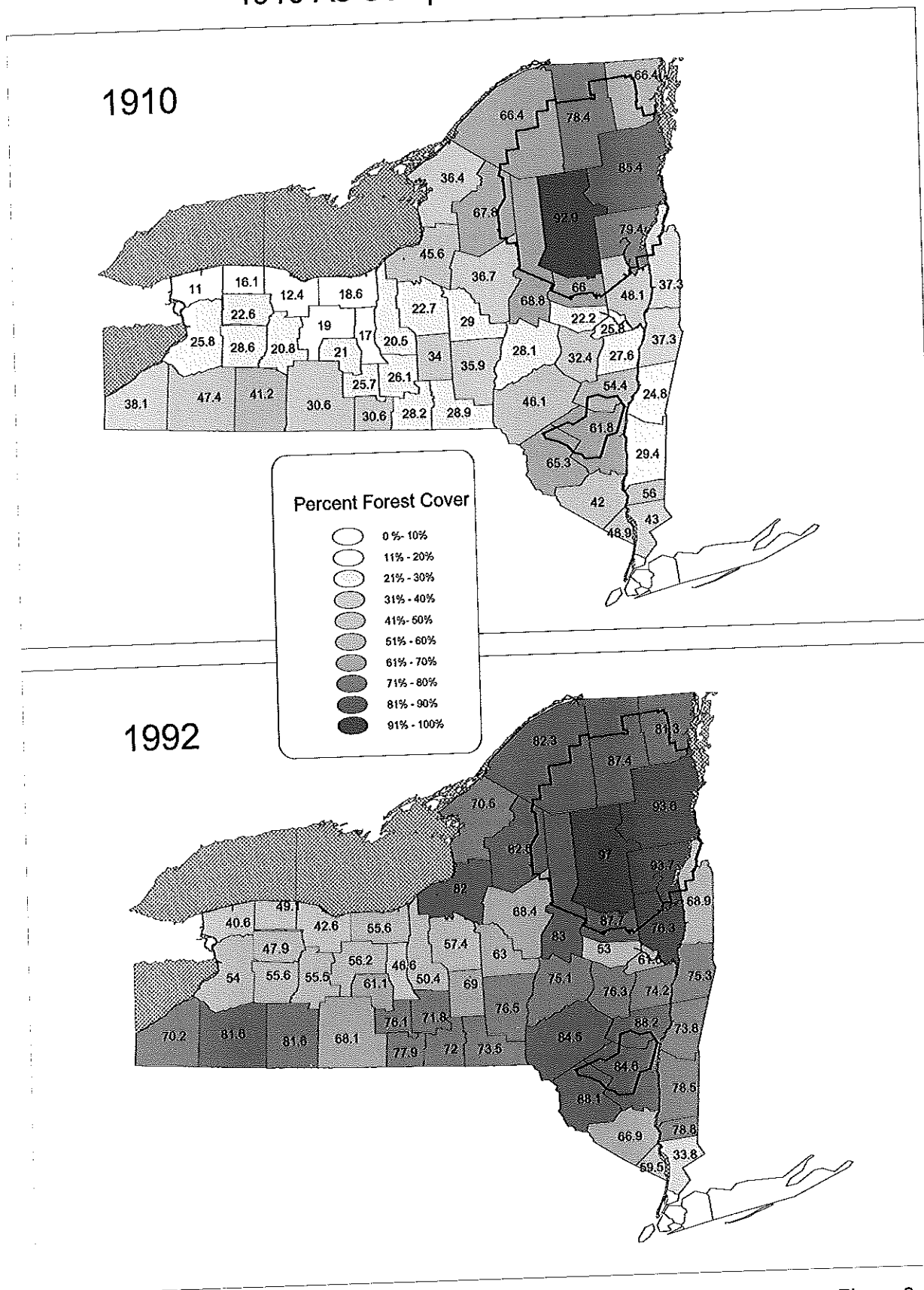


Figure 1

Total Percent Land Area in Woodland
Unimproved and Parks
1910 As Compared to 1992



Legend Coyote Reports Maps

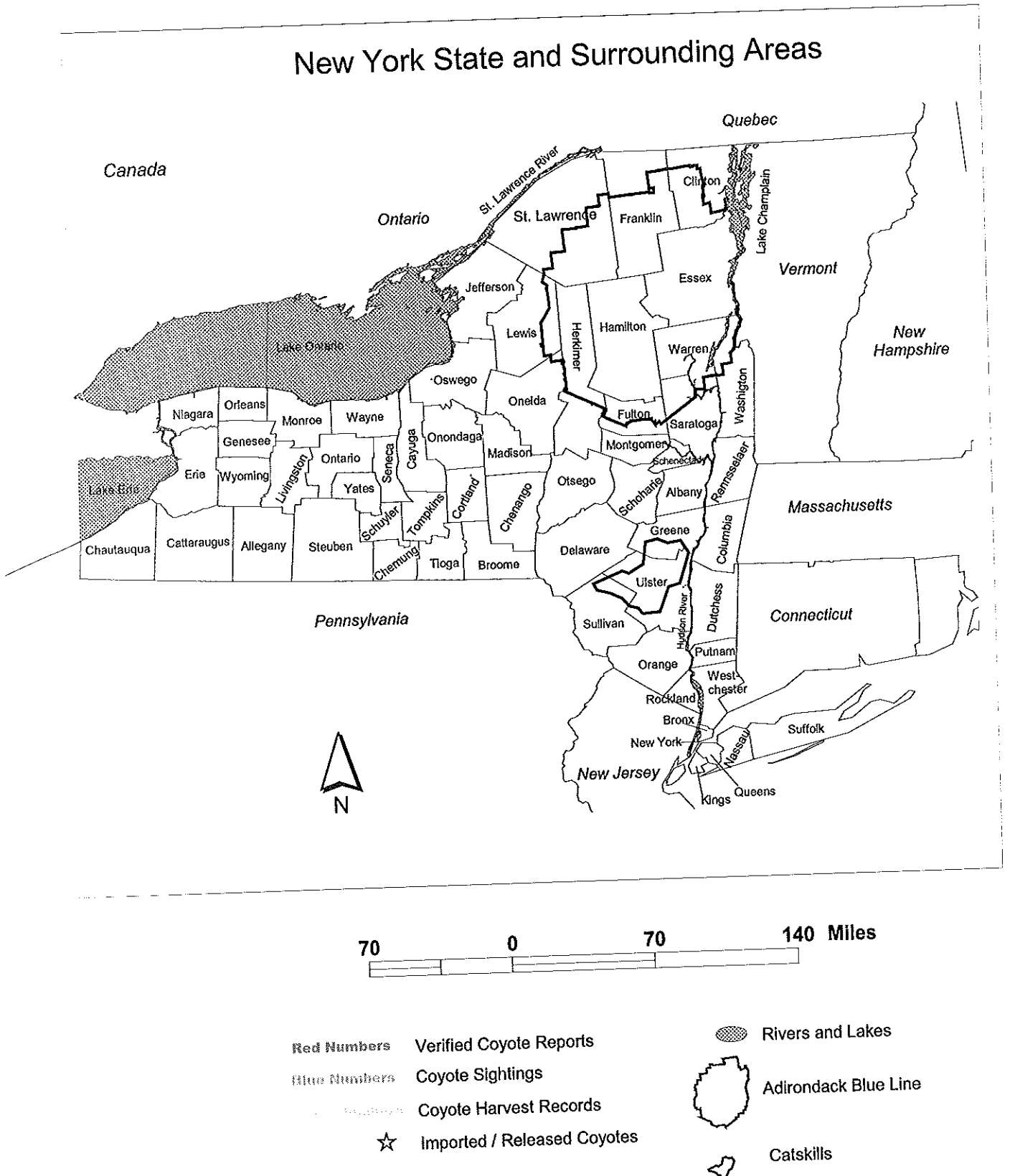
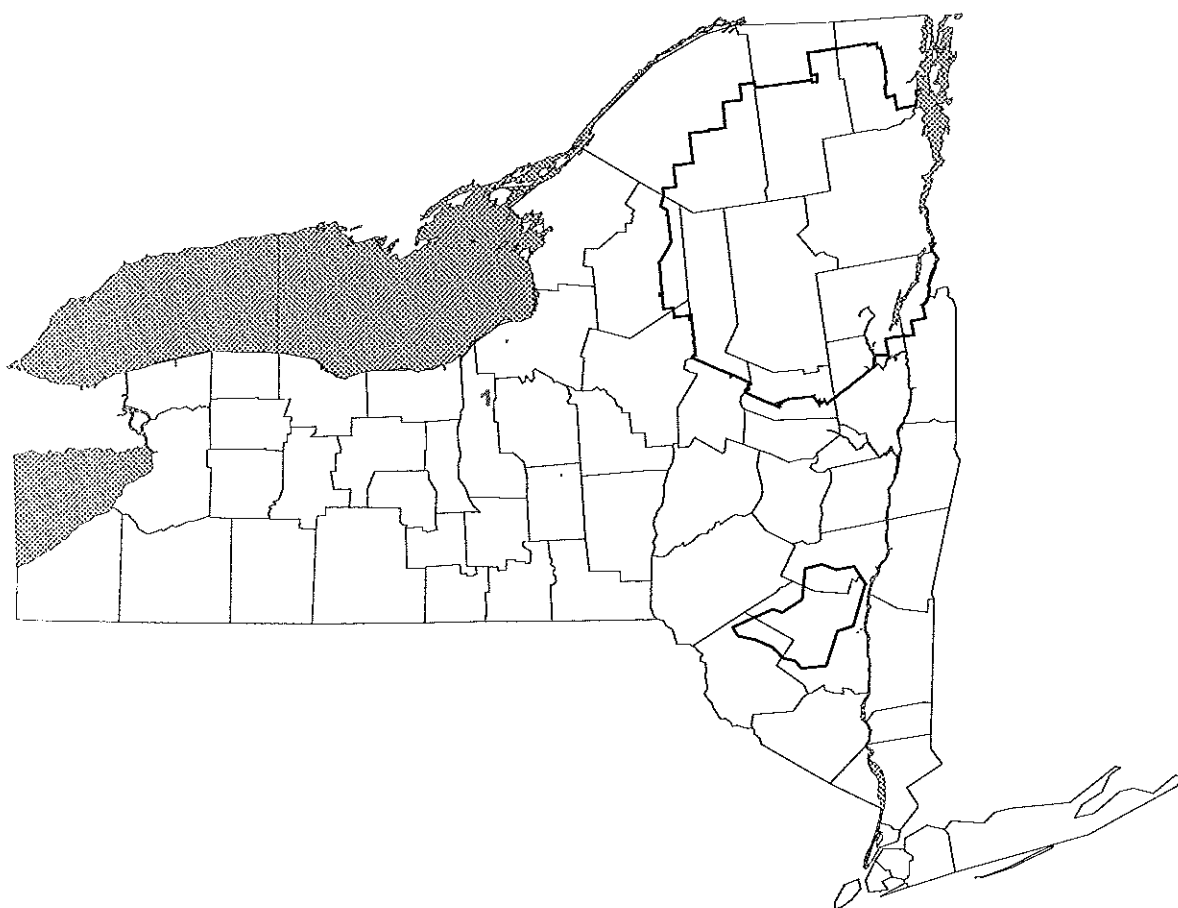


Figure 3

Coyote Reports 1900 - 1910



★₁ 1906 Cayuga County (Port Byron) 1 coyote

Figure 4

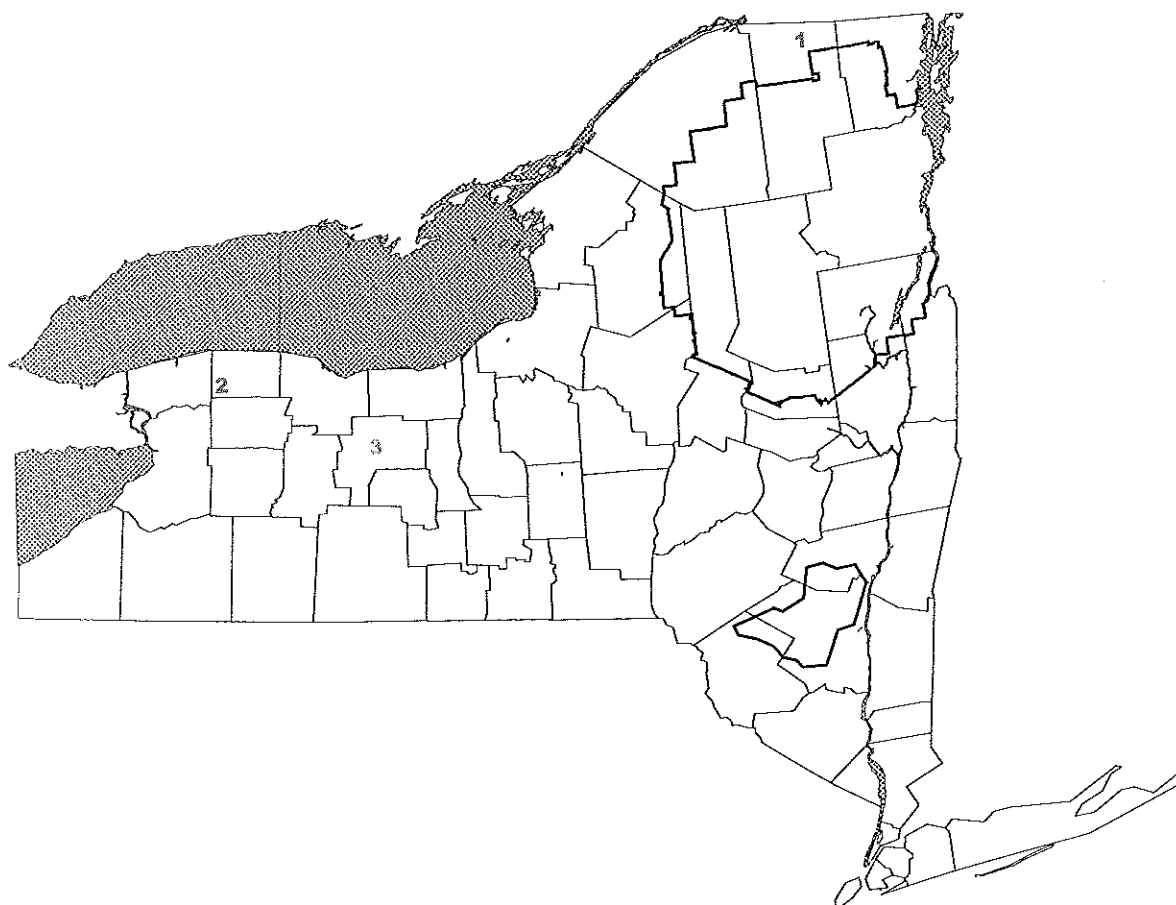
Coyote Reports 1911 - 1920



- ★₁ 1916 Cayuga County (South Bristol) 1 coyote
- ★₂ 1920 Tompkins County (N/A) 1 coyote

Figure 5

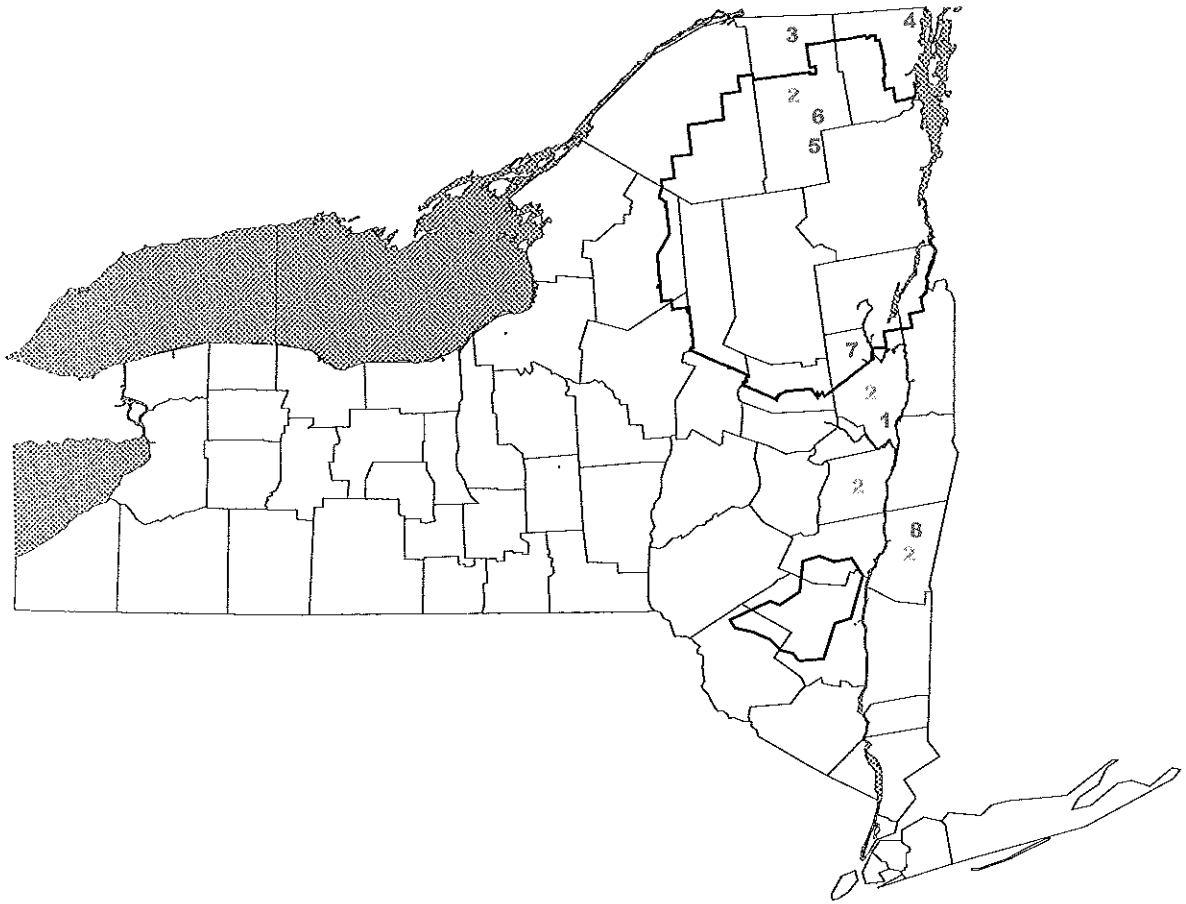
Coyote Reports 1921 - 1930



- 1 1925 Franklin County (Belmont) 1 coyote
- 2 1926 Orleans County (Tonowanda Swamp) 3 coyotes
- ★ 3 1928 Ontario County (N/A) 8 coyotes

Figure 6

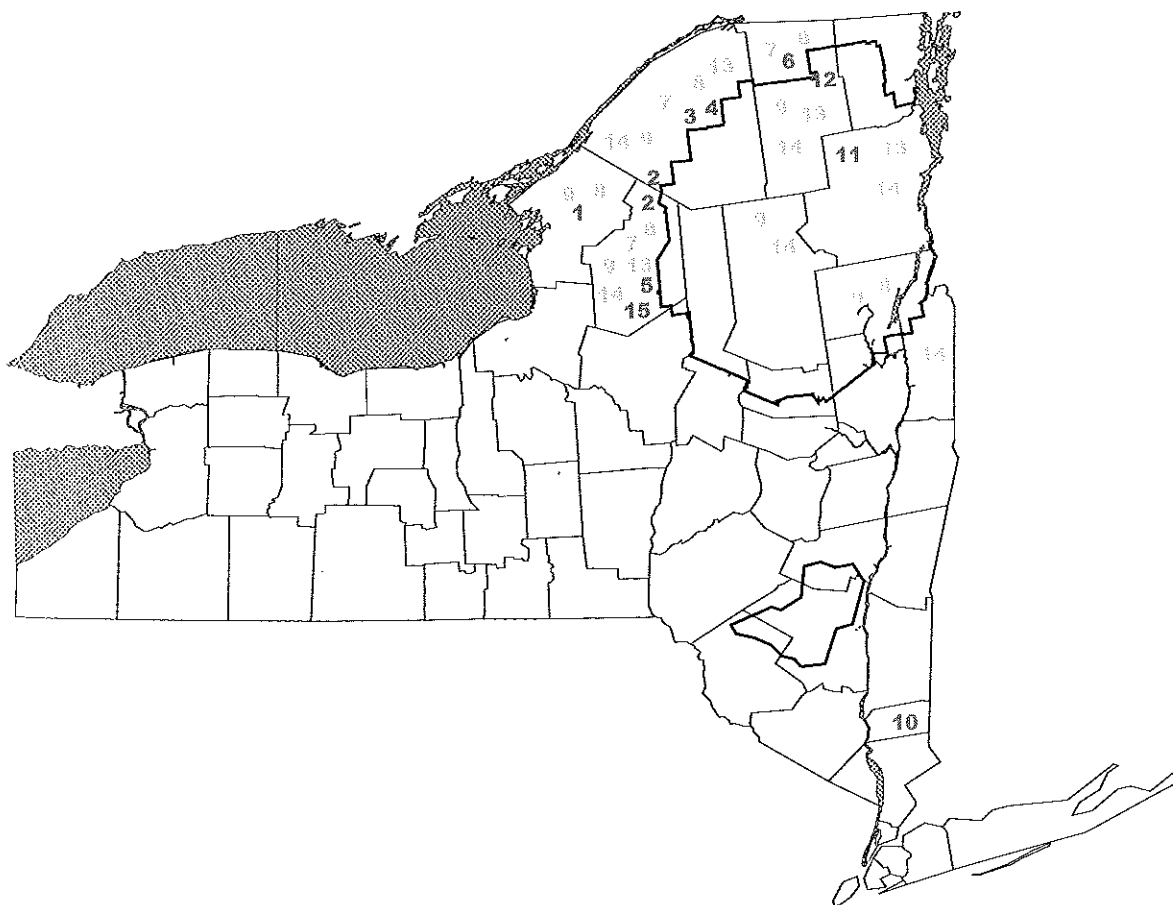
Coyote Reports 1931 - 1940



- 1 1933 Saratoga County (Clifton Park) 1 coyote
- ★ 2 1934 Albany County (N/A)
Columbia County (N/A) unknown number
Franklin County (N/A)
Saratoga County (N/A)
- 3 1934 Franklin County (Belmont) 1 coyote
- 4 1934 Clinton County (Chazy) 1 coyote
- 5 1934 Franklin County (Saranac Lake) 1 coyote
- 6 1935 Saratoga County (Loon Lake) 1 coyote
- ★ 7 1935 Saratoga County (Wayville) 3 coyotes
- 8 1938 Columbia County (N/A) 1 coyote

Figure 7

Coyote Reports 1941 - 1950

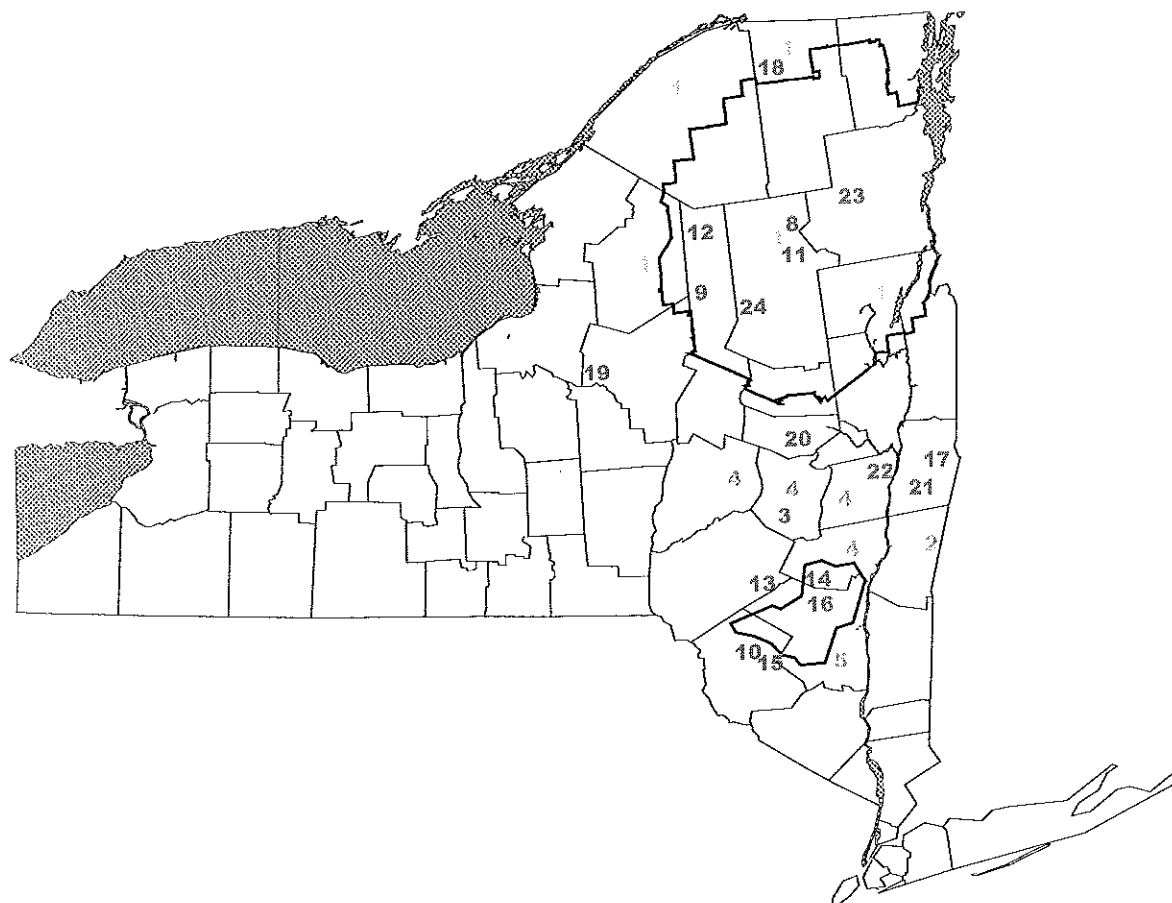


- ★ 1 1941 Jefferson Count (Camp Drum) 6 coyotes
- 2 1942 St. Lawrence County (SW corner)
Lewis County (Harrisville)
- 3 1945 St. Lawrence County (Pierrepoint) 1 coyote
- 4 1946 St. Lawrence County (Colton) 1 "coydog"
- 5 1946 St. Lawrence County (Greig) 1 "coydog"

Figure 8

- 6 1946 Franklin County (Debar Game Refuge)
1 "coydog" and 8 pups
- 7 1946 - 1947 Franklin County (N/A) 5 coyotes
Lewis County (N/A) 10 coyotes
St. Lawrence County (N/A) 19 coyotes
- 8 1947 - 1948 Franklin County (N/A) 6 coyotes
Jefferson County (N/A) 2 coyotes
Lewis County (N/A) 15 coyotes
St. Lawrence County (N/A) 16 coyotes
Warren County (N/A) 1 coyote
- 9 1948 - 1949 Franklin County (N/A) 9 coyotes
Hamilton County (N/A) 5 coyotes
Jefferson County (N/A) 8 coyotes
Lewis County (N/A) 6 coyotes
St. Lawrence County (N/A) 23 coyotes
Warren County (N/A) 1 coyote
- 10 1949 Putnam County (Kent) 1 coyote
- 11 1949 Essex County (Lake Placid) 1 coyote
- 12 1949 Franklin County (Mountain View) 5 coyotes
- 13 1949 Essex County (N/A) 8 coyotes
Franklin County (N/A) 8 coyotes
Lewis County (N/A) 17 coyotes
St. Lawrence County (N/A) 10 coyotes
- 14 1949 - 1950 Franklin County (N/A) 3 coyotes
Hamilton County (N/A) 5 coyotes
Lewis County (N/A) 10 coyotes
St. Lawrence (N/A) 39 coyotes
Warren County (N/A) 3 coyotes
Washington County (N/A) 1 coyote
- 15 1950 Lewis County (N/A) 5 coyote pups

Coyote Reports 1951 - 1960

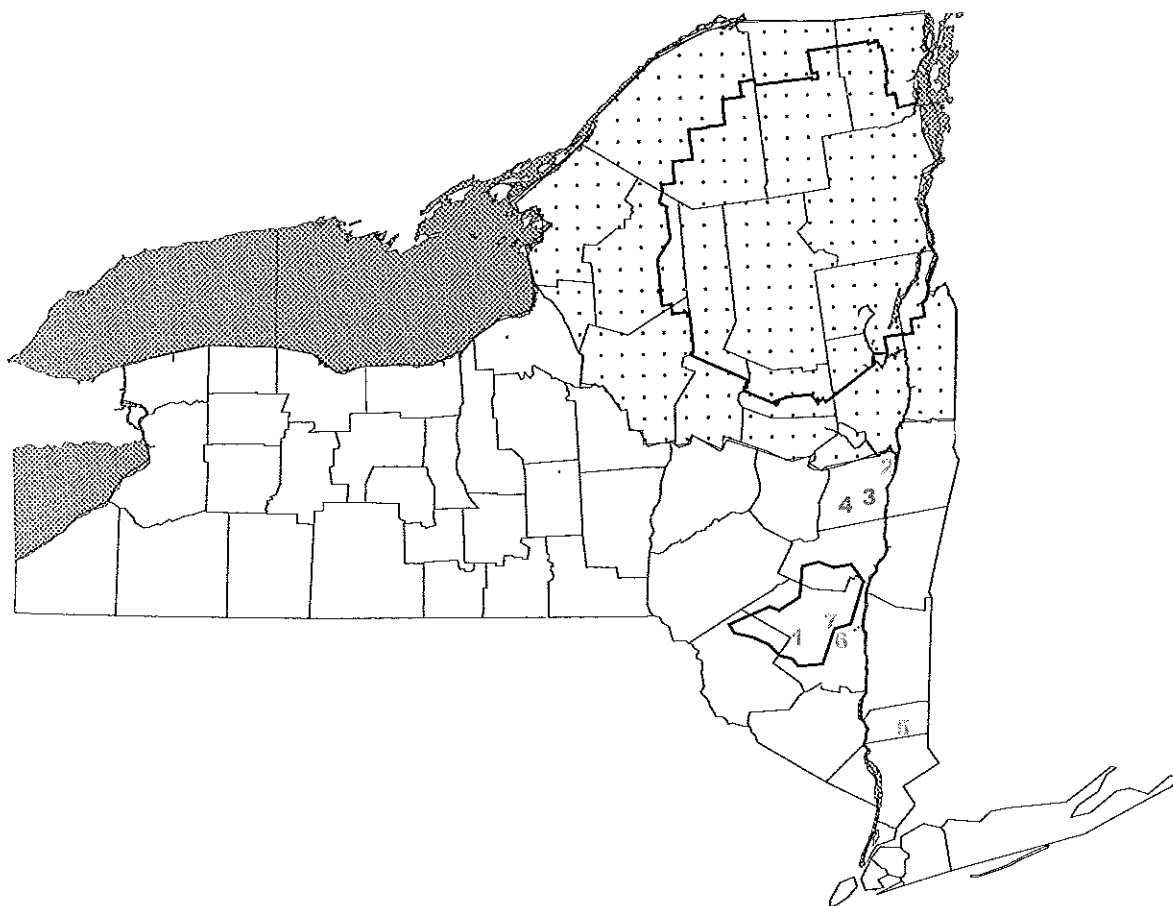


- 1 1950 - 1951 Franklin County (N/A) 5 coyotes
Hamilton County (N/A) 1 coyote
Lewis County (N/A) 11 coyotes
St. Lawrence County (N/A) 35 coyotes
Warren County (N/A) 14 coyotes
- 2 1951 Columbia County (Austerlitz Mountains) pack of "coydogs"
- 3 1951 Schoharie County (Blenheim) 1 coyote
- 4 1951 Albany County (N/A)
Greene County (N/A)
Schoharie County (N/A)
Delaware County (N/A)
- 5 1951 Ulster County (Mohonk Preserve) 1 coyote

Figure 9

- 6 1954 Warren County (Lens Lake) 2 coyotes
- 7 1954 Montgomery County (Fonda) 3 coyotes
- 8 1954 Hamilton County (Long Lake) 8 coyotes
- 9 1954 Herkimer County (Woodhull Lake Dam) 1 coyote
- 10 1955 Sullivan County (Aden) 1 coyote
- 11 1956 - 1957 Hamilton County (Blue Mountain Lake) 1 coyote
- 12 1957 Herkimer County (northern section) 1 coyote
- 13 1957 Delaware County (Roxbury) 1 coyote
- 14 1957 Greene County (Lexington) 1 coyote
- 15 1957 Sullivan County (Neversink) 1 coyote
- 16 1958 Ulster County (Shandaken) 1 coyote
- 17 1958 Rensselaer County (N/A) 1 coyote
- 18 1958 Franklin County (Dickinson) 6 "coydog" pups
- 19 1958 Oneida County (Bernhards Bay) 1 coyote
- 20 1959 Montgomery County (Glen) 1 coyote
- 21 1959 Rensselaer County (N/A) 1 coyote
- 22 1960 Albany County (Latham) 1 coyote
- 23 1956 - 1960 Essex County (Huntington Forest) 1 coyote
Hamilton County (Southern Moose River) 1 coyote

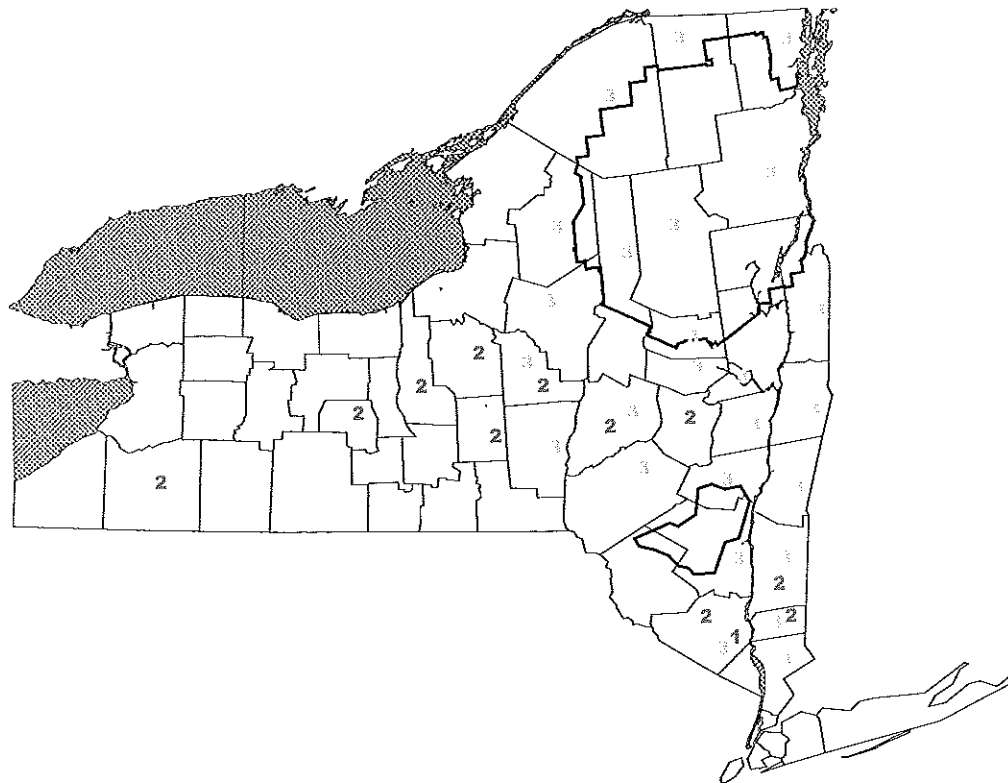
Coyote Reports 1961 - 1970



- 1 1961 Ulster County pack of "coydogs"
- 2 1963 - 64 Albany County numerous sightings
- 3 1964 Saratoga County 1 coyote
- 4 1966 Saratoga County 1 coyote
- 5 1966 Putnam County/Taconic Parkway 1 coyote
- 6 1967 Ulster County Woodstock 1 coyote
- 7 1970 Ulster County/Mohonk Preserve 1 coyote

Figure 10

Coyote Reports 1971 - 1980



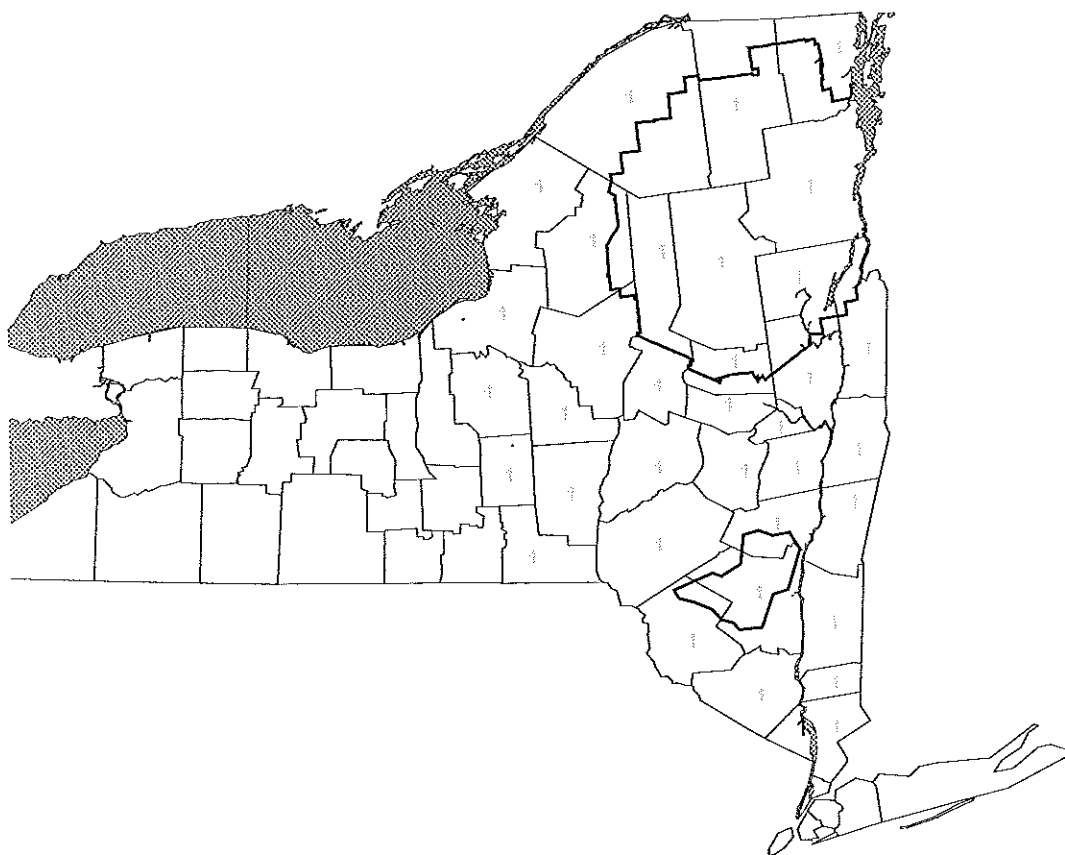
1 1970 - 1974 Orange County (Black Rock Forest)
< 1 coyote

2 1971 - 1974 Broome County (n/a)
Cattagaurus County (n/a)
Cayuga County (n/a)
Cortland County (n/a)
Dutchess County (n/a)
Madison County (n/a)
Onondaga County (n/a)
Orange County (n/a)
Otsego County (n/a)
Putnam County (n/a)
Schoharie County (n/a)
Yates County (n/a)

Figure 11

1979 - 1980	Albany County	14
	Chenango County	18
	Clinton County	84
	Columbia County	37
	Delaware County	30
	Dutchess County	33
	Essex County	125
	Franklin County	189
	Fulton County	56
	Greene County	74
	Hamilton County	118
	Herkimer County	165
	Lewis County	153
	Madison County	19
	Montgomery County	36
	Oneida County	166
	Orange County	2
	Otsego County	38
	Putnam County	18
	Rensselaer County	53
	Saratoga County	64
	Scenectady County	16
	St. Lawrence	478
	Ulster County	32
	Warren County	53
	Washington County	54
	Westchester County	2

Coyote Reports 1981 - 1990

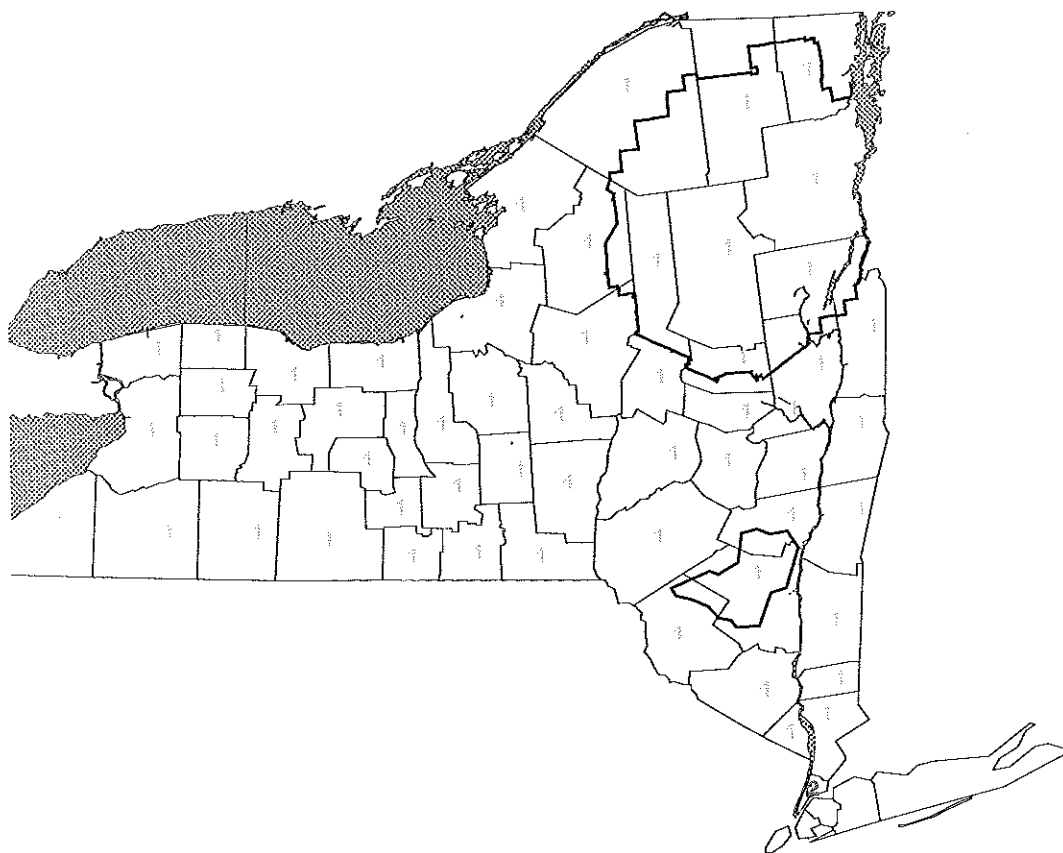


1981 - 1990	Albany County	151
	Chenango County	168
	Clinton County	645
	Columbia County	280
	Delaware County	394
	Dutchess County	245
	Essex County	447
	Franklin County	862
	Fulton County	308
	Greene County	237
	Hamilton County	437
	Herkimer County	541

Figure 12

Lewis County 961
Madison County 162
Montgomery County 195
Oneida County 634
Orange County 98
Otsego County 218
Putnam County 55
Rensselaer County 220
Rockland County 9
Saratoga County 445
Schenectady County 45
St. Lawrence County 1,770
Ulster County 294
Warren County 260
Washington County 399
Westchester County 34

Coyote Reports 1991 - 1999



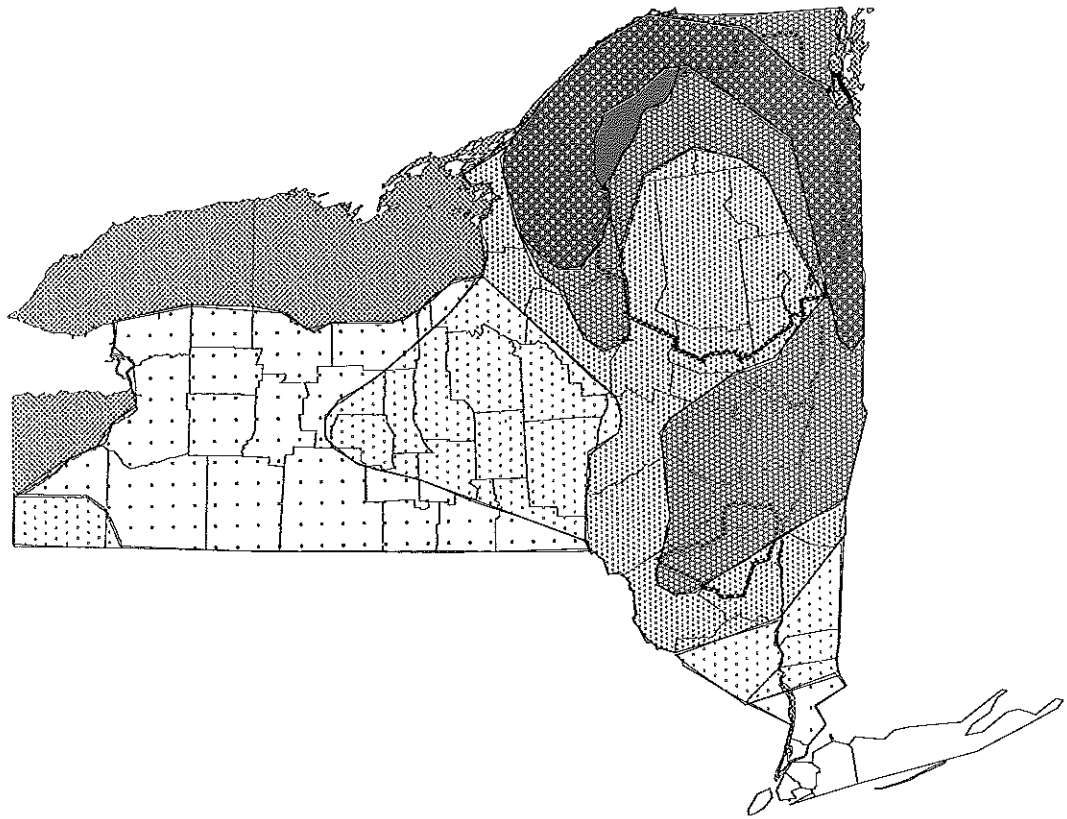
1981 - 1990	Albany County	192
	Chenango County	261
	Clinton County	521
	Columbia County	330
	Delaware County	619
	Dutchess County	353
	Essex County	498
	Franklin County	805
	Fulton County	350
	Greene County	277
	Hamilton County	275
	Herkimer County	531

Figure 13

Lewis County 1,143
Madison County 264
Montgomery County 323
Oneida County 794
Orange County 233
Otsego County 562
Putnam County 27
Rensselaer County 343
Rockland County 19
Saratoga County 415
Schenectady County 90
St. Lawrence County 986
Ulster County 379
Warren County 139
Washington County 384
Westchester County 53

2 1995 New York County / Central Park
1 coyote

Coyote Colonization Pattern in New York State 1940 - 2000



Legend







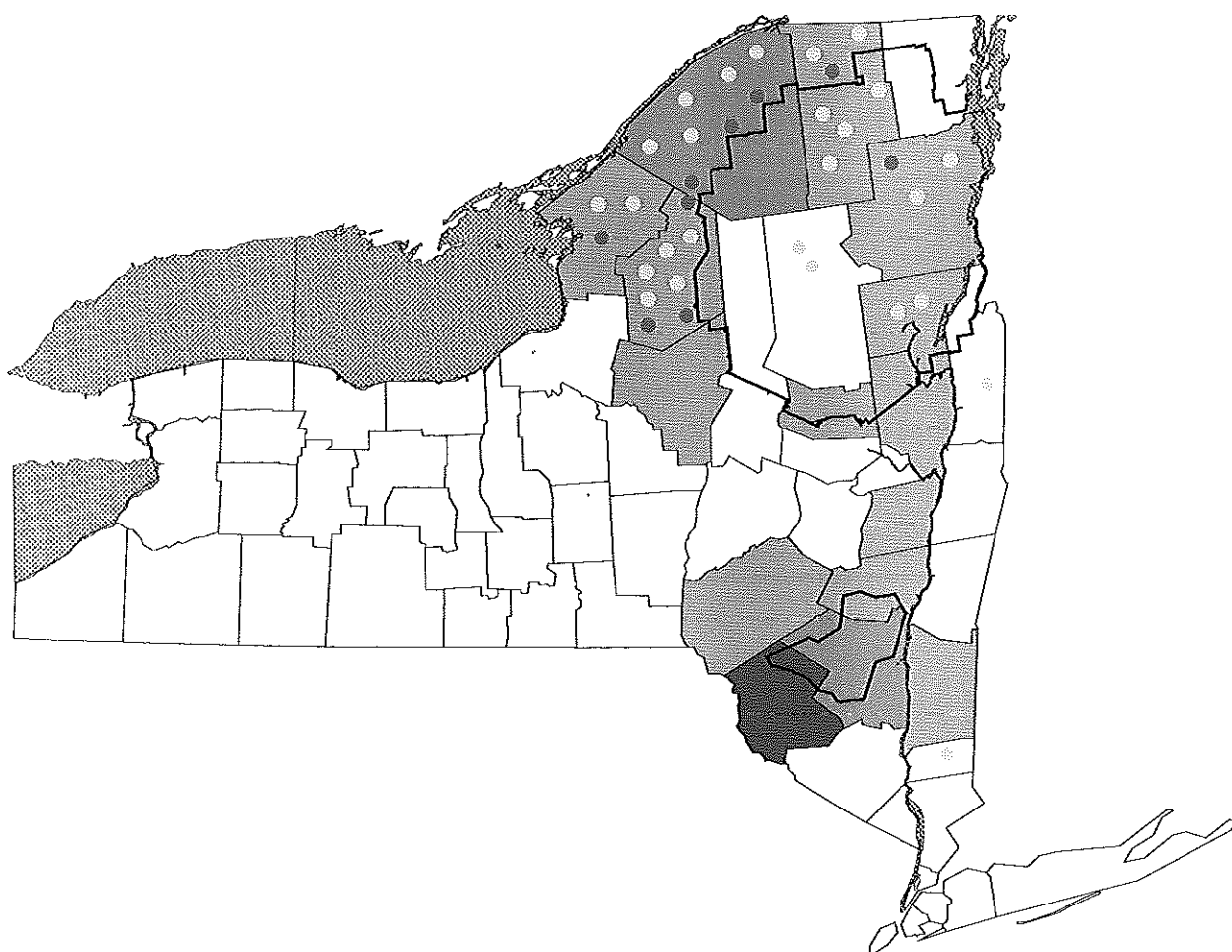
-  Coydog Population 1940 - 1945
-  Coyote Range 1940 - 1950
-  Coyote Range 1950 - 1955
-  Coyote Range 1955 - 1965
-  Coyote Range 1965 - 1975
-  Coyote Range 1975 - 2000



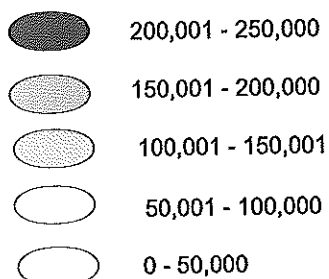
Figure 14

Cumulative Farmland Loss & Coyote Colonization 1921-1950



Legend

Farmland Loss in Acres





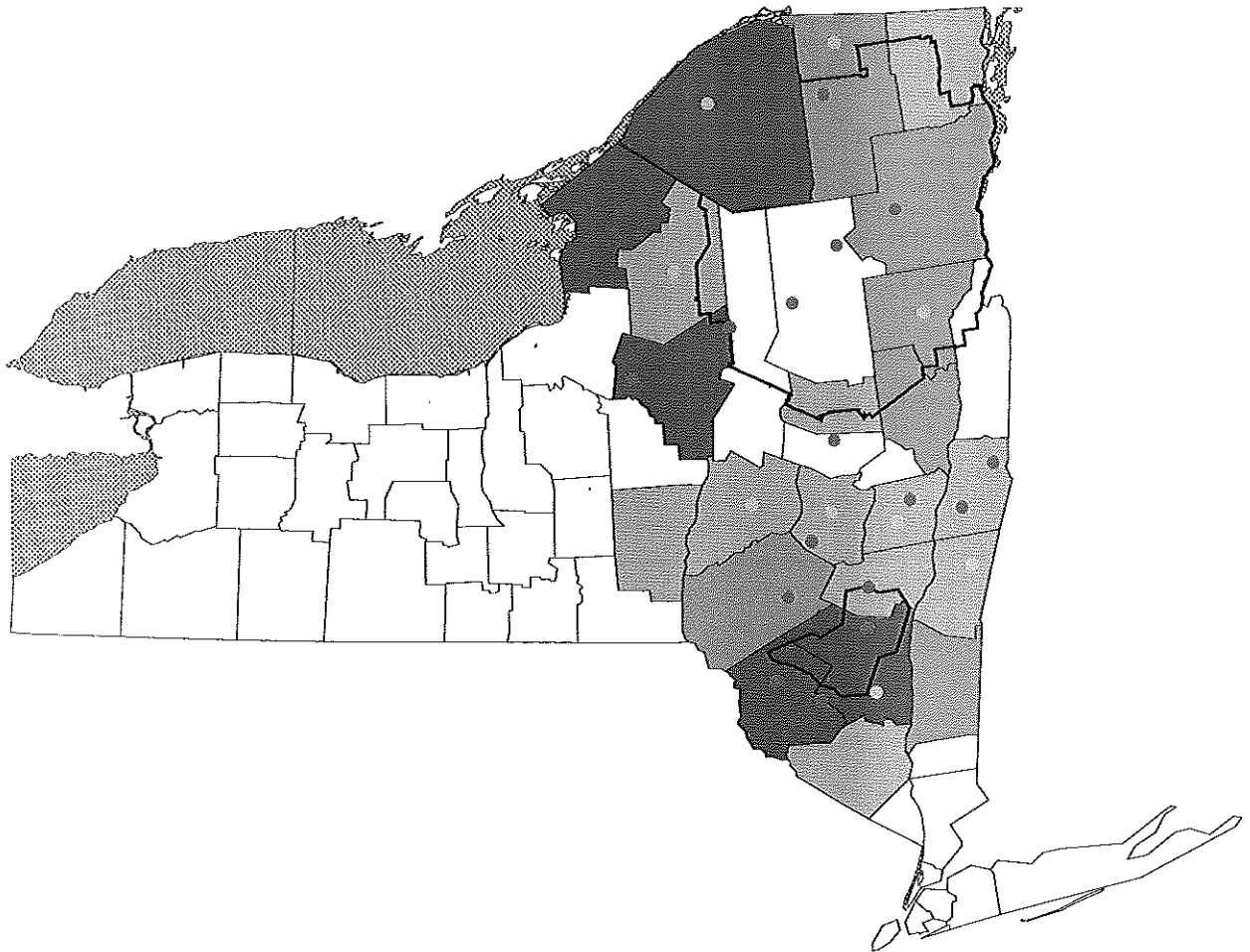
- | | |
|--|-------------------------|
|  | Verified Coyote Records |
|  | Coyote Harvest Records |



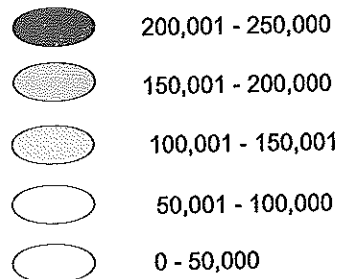
Figure 15

Cumulative Farmland Loss & Coyote Colonization 1921 - 1960



Legend

Farmland Loss in Acres



- Verified Coyote Records
- Coyote Sightings
- Coyote Harvest Records



Figure 16

Table 1

Field Stations	
Name	Established
Cornell Biological Field Station at Shackleton Point	1956
Edmund Niles Hyuck Preserve & Biological Field Station	1935
Harriman State Park	1910
Biological Field Station in Cooperstown	n/a
Adirondack Ecological Center	1932
Institute of Ecosystem Studies	1983
Albany Pine Bush	1988
Bard College Field Station & Hudsonia Ltd.	1971
Hartwick College Biological Station	1971
Louis Calder/Biological Field Station (Fordham University)	1967

Table 2

Coyote Bounty Records						
County	Bounty Price	# Coyotes Taken				
		1946-47	1947-48	1948-49	1949-50	1950-51
St. Lawrence	\$50	19	16	23	39	35
Lewis	\$25	10	15	6	10	11
Jefferson	\$35	0	2	8	0	0
Franklin	\$35	5	6	9	3	5
Warren	\$75	0	1	1	3	14
Hamilton	\$25	0	0	5	5	1
Washington	\$35	0	0	0	1	0