A Summary of The Final Report

The Ecology and Interactions of White-tailed Deer and Eastern Coyotes as Influenced by Human Activities in Nova Scotia

By
Brent R. Patterson
Bevan A. Lock
Bruce A. Macdonald

December 1999

NOVA SCOTIA
Natural Resources

Foreword

Toward the end of the 1980s Nova Scotia's deer population was declining while its coyote population was increasing. This brought on public concern that coyotes were reducing deer numbers, adding pressure on a deer herd they felt was already suffering due to clear cutting of winter habitat. Wildlife biologists had little local information to explain what was happening.

To get scientifically defensible data on these events, the Wildlife Division of the Department of Natural Resources initiated a study of deer wintering behaviour and the effects of coyote predation and forest harvesting on the deer herd. Three graduate students (two M.Sc. candidates and one PhD candidate) from Acadia University's Centre for Wildlife and Conservation Biology, were the principal researchers in the project. Funding was provided in part under the Canada/Nova Scotia Cooperation Agreement for Forestry Development 1991–95.

This document is a summary of the researchers' final report to the Department. Opinions expressed are those of the researchers and not necessarily those of the Department of Natural Resources.

A. P. Duke
Manager Wildlife Resources
December, 1999

Contents

Section 1

Aspects of The Ecology of White-tailed Deer in Nova Scotia

1.1 Introduction

When Europeans first arrived in Nova Scotia in the 1600s, they did not encounter any white-tailed deer. In 1908, nine white-tailed deer were released in the province near Bear River, Digby County. Food was abundant and their numbers soon swelled. In 1916, a hunting season for bucks only was begun in some counties, and by 1940 the season was opened province-wide for two animals of either sex to each hunter. Over the next 50 years the number of white-tailed deer in Nova Scotia continued to increase, except for brief population crashes in the 1950s and early 1970s. By the winter of 1986–87, their numbers had apparently exceeded the province's carrying capacity and crashed again – in spite of liberal hunting regulations and the rapid increase in the numbers of eastern coyote in the province.

Deer in Nova Scotia are at the northern limit of their range, and are affected by a number of factors including losses due to winter malnutrition; predation by coyotes, bobcats, and domestic dogs; vehicle collisions; and legal and illegal harvest. Approximately 80 per cent of Nova Scotia is forested, and forestry is an important industry in the province. For deer, the best feeding comes from small, scattered cuttings rather than large cuts, which also provide less cover in severe weather conditions.

The key to maintaining a stable deer population is in understanding how all these limiting factors interrelate, as well as being able to evaluate (or estimate) and manipulate one or more factors. Wildlife managers generally have the most control over legal hunting, and in 1993 Nova Scotia instituted a province-wide buck law limiting

hunters to taking males only. That same year, the Department of Natural Resources (DNR) began a four-year study to examine the effects of landscape patterns, forest harvesting, winter severity, and coyote predation on deer survival in the province.

This is a summary of that study. The full report and other relevant documentation is available at the DNR library, Halifax, Nova Scotia.

1.2 Study Areas

Two distinct geographic areas of the province were chosen for our investigation (Figure 1). These areas were selected to allow an examination of the effects of winter severity and differing prey densities on deer and coyote life histories, and to study coyote-deer interactions in Nova Scotia.

The Queens County study area was located in central southwestern Nova Scotia, and included the eastern half of Kejimkujik National Park (about 200 sq km) and 300 sq km of primarily forested land east of the park. This area generally receives accumulations of less than 20 cm of snow in winter. For brevity, it is referred to as QC in this report.

The Cape Breton study area (CB) was centered around the 24 sq km Eden deer wintering area (DWA), which typically contains about 200 deer from January through March. The Cape Breton area has two distinct elevation zones: the Creignish Hills at about 300 m above sea level (CBH, Cape Breton Highlands), and the River Denys Basin (CBL, Cape Breton Lowlands).

Figure 1
Locations of the QC, CBH, and CBL study areas.
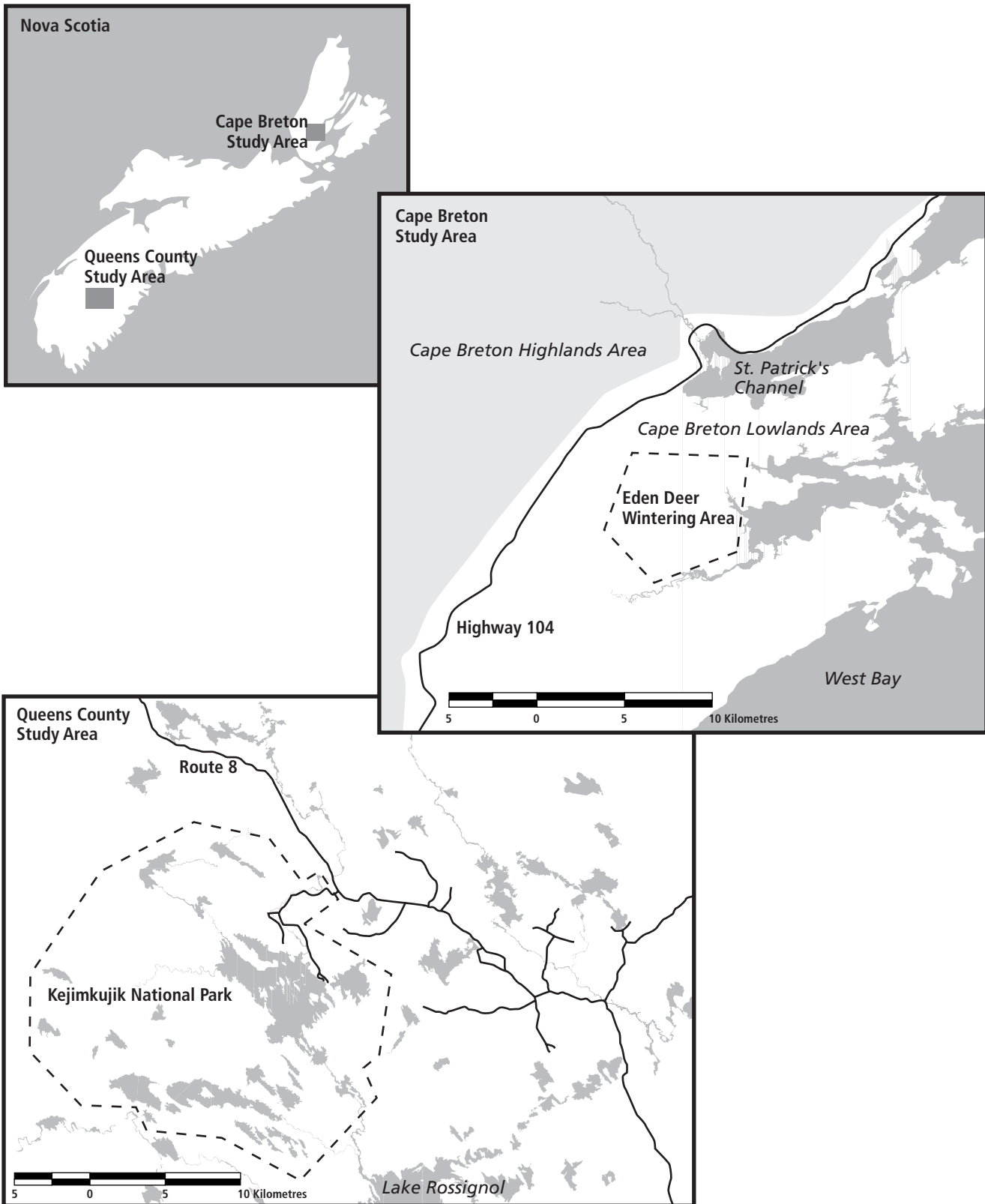
1.3 Deer Population Trends

Deer numbers in Nova Scotia have fluctuated since their introduction at the beginning of the century. We estimated current deer numbers by counting their pellet groups along 30 survey lines, 1 km long and 2 m wide, in both study areas each spring.

Although deer were evenly distributed thoughout CB from May through November, most deer then migrated to their wintering grounds in CBL.

Based on the pellet group surveys, estimates of winter deer density averaged around 5.5 deer/sq km in CBL, 2.2 deer/sq km in CBH, and 9.8 deer/sq km in the Eden DWA. However, fewer deer – only 4.7 deer/sq km – migrated to the Eden DWA during the mild winter of 1995. Estimates for the QC area were consistently lower, at 2.5 deer/sq km, with a relatively even distribution.

Figure 2
The relative abundance of white-tailed deer in the Queens County (QC) and Cape Breton (CB) study areas, 1992–1997.
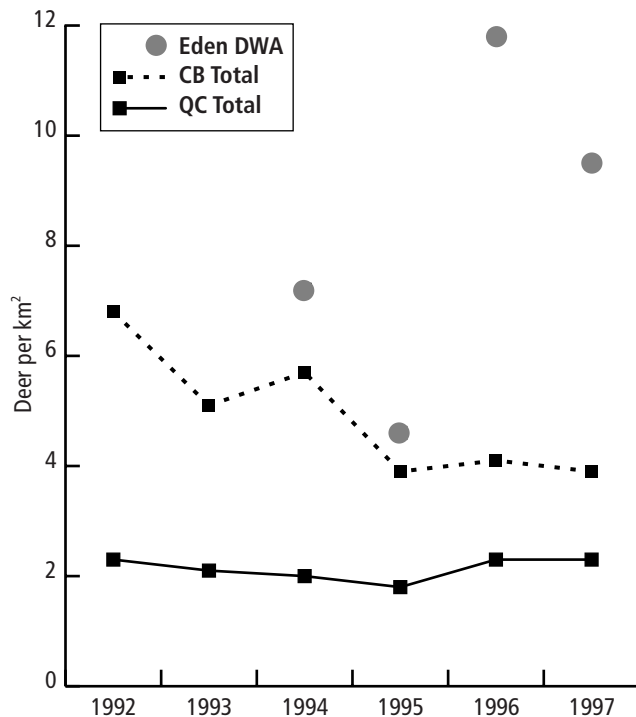
To gain a clearer picture of the winter distribution of deer in CB we also conducted aerial and ground surveys during the winters of 1996 and 1997. The results of these surveys are summarized in Figure 2, and show a clear difference in the winter distribution of deer between the highlands and the lowlands.

1.4 Deer Survival: Causes and Rates of Mortality

A major difficulty in the analysis of wildlife population dynamics is in obtaining reliable estimates of survival. Most studies have concluded that hunting is the major cause of mortality in exploited deer populations. As a result, harvest by hunters is frequently targeted by deer management plans. More recently however, studies conducted in northern New Brunswick and on Vancouver Island in British Columbia concluded that predation was the major source of mortality. At present, our lack of knowledge of non-hunting mortality rates is hindering the effective management of white tailed deer populations.

Deer capture and handling
Between February 1994 and March 1997, we captured 124 deer and fitted them with radio-collars. Capture methods included box trapping, trapping with a ground-based rocket net, shooting with drug-loaded darts, and netting from a helicopter. The radio collars contained mortality switches that doubled the pulse rate of the emitted signal if the collar remained motionless for more than six hours.

Collared deer were checked for mortality signals at least twice a week from April to mid-October, and four times a week through the rest of the year. When a dead deer was located, the site and carcass were examined to determine the cause of death. A mortality was classified as a predator kill if there was evidence of attack or chase. We identified the species of predator involved from tracks, bite marks, and other related signs.

Causes of death

We documented 45 deaths during a period of monitoring equivalent to 293 "deer-years," where one deer-year equals 365 days of telemetry contact with deer. It could be the result of monitoring a single deer for one year, or several deer for a total of 365 contact days.

Sixteen deaths were due to predation (11 coyote, 3 bobcat, 1 lynx, 1 unknown), 9 to registered harvest, 12 to unregistered harvest, 4 to malnutrition, and 4 to other natural causes. Unregistered harvest includes deer that were illegally harvested, lost due to wounding, or harvested but not reported by aboriginal people. Harvest by hunters was the most significant cause of death for adult males in both study areas. In spite of the fact that legal non-aboriginal hunting was restricted to bucks only starting in 1993, there was little effect on herd productivity, as does produced fawns at rates appropriate for their age throughout this study. However, there was no noticeable increase in deer numbers until 1997. Given the mild winters during this period, it seems likely that predation and illegal harvest of antlerless deer were to blame.

Deer survival rates

Beginning with the birth of the new fawn crop, assumed to be June 1, we divided the biological year into four intervals approximating to summer, fall (which includes all days in bow and firearm seasons), winter, and spring. The results are shown in Figure 3.

Only deer collared for more than 12 days were included in survivorship estimates. Separate rates were calculated for adult (more than one year) males, adult females, and fawns – although fawns were grouped with adults when there were not enough data to consider them alone. In QC separate comparisons were made for deer living inside and outside Kejimkujik National Park.

Annual survival rates ranged from 41.9 per cent for adult males in CB to 94.6 per cent for adults in Kejimkujik National Park (where only two deaths occurred, both females). Survival rates were significantly lower for males than females in both areas due to sex-biased harvesting, higher winter mortality, and higher predation rates. In QC, survival rates were significantly higher for deer living within Kejimkujik National Park. As predation was the only cause of death for deer in Kejimkujik, and predation rates were virtually the same within and outside the park, hunting-related mortalities outside the park were clearly responsible for the lower survival rates we observed.

The annual survival rates of fawns were approximately 44 per cent in CB, and approximately 47 per cent in QC. These are higher than annual survival rates from studies in New Brunswick and Minnesota, but similar to those documented in Quebec. Many factors influence fawn survival, including harvest levels, predation, winter severity, and habitat quality, so regional differences in survival are expected. Survival rates of fawns in both areas were lower than those of adult females between December and May.

We examine the effects of hunting and predation in more detail in section 2.3

Figure 3
Survival and cause specific mortality rates, of radio-collared white-tailed deer monitored in the Queens County and Eden Study Areas, February 1994 – March 1998.

Cohort	Dec 10 – March 31		April 1 – May 31		June 1 – Sept I5		Sept 16 – Dec 9		Annual	
	Rate	No. Radiodays	Rate	No. Radiodays	Rate	No. Radiodays	Rate	No. Radiodays	Rate	No. Radiodays
CB Adult Females	**0.943**	**7645**	**0.972**	**4330**	**0.975**	**8629**	**0.912**	**6460**	**.815**	**27064**
Predation[1]	0.057		0.014		0.012		0.013		(9.3%)	
Registered harvest							0.0		(0.0%)	
Unregistered harvest[2]							0.075		(6.7%)	
Natural mortality[3]			0.014		0.012		0.0		(2.4%)	
CB Adult Males	**0.701**	**948**	**1.0**	**771**	**1.0**	**1537**	**0.597**	**993**	**.419**	**4249**
Predation	0.I00						0.067		(14.7%)	
Registered harvest							0.268		(18.8%)	
Unregistered harvest							0.067		(4.7%)	
Natural mortality	0.199								(19.9%)	
CB Fawns	**0.634**	**492**	**0.936**	**923**						
Predation	0.183									
Natural mortality	0.183		0.064							
QC Adults (Park)[4]	**0.970**	**3728**	**1.0**	**2179**	**0.975**	**4267**	**1.0**	**3393**	**.946**	**13192**
Predation	0.030				0.025				(5.4%)	
QC Adult Fem. (Non Park)[5]	**0.936**	**3436**	**0.974**	**2347**	**1.0**	**4793**	**0.851**	**2761**	**.778**	**13247**
Predation[3]	0.032		0.026				0.147		(5.6%)	
Registered harvest										
Unregistered harvest									(13.4%)	
Natural mortality	0.032								(3.2%)	
QC Ad. Males (NonPark)[5]	**0.936**	**3436**	**0.974**	**2347**	**1.0**	**4793**	**0.544**	**741**	**.496**	**11317**
Predation[3]	0.032		0.026						(5.6%)	
Registered harvest							0.263		(24.0%)	
Unregistered harvest							0.175		(16.0%)	
Natural mortality	0.032								(3.2%)	
QC Fawns (Non Park)	**0.646**	**566**	**1.0**	**838**						
Predation[2]	0.164									
Natural mortality	0.164									

1   Of the 16 instances of predation observed during this study, 11 were attributed to coyotes, 3 to bobcats, 1 to a lynx, and 1 unknown.

2   Unregistered harvest includes deer which were known or suspected to have been illegally harvested, abandoned or lost (wounding loss), or harvested and not reported by aboriginal people.

3   Natural mortality includes deaths from malnutrition, old age, accidents, or other naturally occurring sources (excluding predation).

4   Males and females were pooled for this analysis since we had little data on males in the Park and no males died within the Park. There was not enough data to consider the survival rates of fawns in the Park.

5   Data for males and females was pooled except during autumn because we observed no male moralities during other times of the year.

1.5 Deer Distribution and Movements

In this part of the study we examined the effects of climate, geography, predation, and human use of the landscape on seasonal distribution of deer, their survivorship, activity, and winter physical condition in Nova Scotia.

Migrations are the seasonal movements of an individual deer from a winter home range to a summer home range area and vice-versa. *Dispersals* differ from migration, as they are "one-way" movements away from the animal's place of birth. In many areas, male deer disperse before reaching sexual maturity, which may be a means of avoiding inbreeding.

Migrations

During the four-year study, radio-collared deer were relocated mostly from the ground, using portable receivers and antennae. The actual location of an animal was determined by taking the mid-point of at least two bearings within a 10-minute time interval. This technique is accurate to within about 90 m at a range of 1 km. A helicopter was used when deer could not be located from the ground.

In CB between 14 per cent of collared deer (4 of 29 animals, winter 1997) and 67 per cent of collared deer (12 of 18 animals, winter 1994) migrated to the Eden DWA. In QC we only noted migrations during the winter of 1994, when 36 per cent of collared deer (4 of 11 animals) migrated to feed in the vicinity of forest harvesting operations. Migration distances in both areas averaged just under 10 km.
Our observations indicate that deer in Nova Scotia mostly migrate in response to snow that is more than 20 cm deep.

Yarding

Yarding is a behaviour learned by deer in regions that normally have severe winter weather. The animals migrate to their wintering areas ("deer yards") before deep snow hampers their movements and makes them vulnerable to predators. Most deer migrated from CB to the Eden DWA by early January, and returned in April. The trigger to return to summer ranges seemed to be mean weekly temperature highs of +5°C and lows of -5°C. Deer may benefit from delaying the return to their summer ranges until the risk of snow storms has diminished. However, we noted that some deer made several trips between their summer and winter ranges if the weather was suitable, even though they had already migrated to the Eden DWA. Overall, it seems that deer in Nova Scotia congregate in winter yards only when conditions warrant it.

Dispersal movements

Dispersals were noted primarily among yearling males. Of 18 males monitored to the end of their second fall, nine dispersed an average of 19 km, mostly in late summer or early fall. By comparison, of 15 older males that were monitored for just over a year, none dispersed. We noted only five dispersals by female deer during 137 deer-years of monitoring.

Seasonal home range use

Deer home ranges in CB were smaller than those in QC during winter, but slightly larger in summer. About twice as much winter food is available in CB than in QC, whereas during the summer, food was plentiful in both areas.

The influence of forest harvesting on deer movements and activity patterns

Extensive clear cutting has caused deer to abandon many wintering areas throughout northeastern North America. New guidelines now limit the size of clear-cuts throughout the region. In Nova Scotia, no single clear-cut in any area designated as a DWA should exceed 10 hectares. With the exception of very small DWAs, a disturbance of this size may do no more than locally displace some deer while providing an abundance of winter food. Many authors have noted that deer are attracted to forest harvesting operations in winter as a source of food. In spite of this, harvesting operations create disturbances that may cause deer to expend excessive energy.

We tested the effects of controlled harvesting on deer movements in winter by cutting within the known home ranges of collared deer, then monitoring their subsequent movements. Ten hectares of forest were harvested in the Eden DWA – on Crown land and adjacent private land – in accordance with the *Forest/Wildlife Guidelines and Standards for Nova Scotia* (1989). To properly assess the extent of our disturbance, we monitored deer activity patterns before, during, and following harvest operations.

During felling, deer moved out of the harvest area temporarily, although many of these same animals would return to feed there "after-hours." Though it seems our forestry operations did not cause a permanent displacement of deer outside their home range, and did not result in an increase in deer activity, the harvest took place during a particularly mild winter when the animals had little need for thermal cover and were able to move about freely to forage. The results might have been different had we been able to conduct this experiment during a severe winter. Current standards in the Guidelines should meet the needs of deer, but the planning of forest harvest operations in and around DWAs must consider their needs during severe winters, even if these occur infrequently.

1.6 Deer Habitat Assessment

Carrying capacity – the maximum number of animals that a particular area of habitat can support for an extended period of time – is affected by factors such as the composition and density of vegetation, the preferences of deer for different types of forage, and the abundance of preferred forage.

In this part of the study we determined the potential amount of forage available per hectare in each study area – ie, the total amount of woody forage within the physical reach and capability of deer – as well as the amount actually browsed by deer. In both study areas typical winter food for deer (stems of woody species) from sample plots was tallied, gathered, then dried and weighed, during spring and fall of 1994–95 and 1995–96. Total available browse was represented by stems located between 0.3 and 2.0 metres above the ground.

The QC study area had an average of 10,660 stems per hectare, whereas the CB area averaged more than twice this amount, 22,790 stems per hectare. In QC the preferred species included red maple, witch hazel, wild raisin, and red oak. In CBL red maple, wild raisin, and aspen were preferred.

In QC the majority of available stems were located in the regenerating type of cover, rather than in mature cover types. In contrast, in CB there were rather more stems available in all mature cover types combined (hardwood, softwood, and mixed-wood), but there were significantly more stems available in regenerating cover types than in mature softwood cover.

The mean mass of browsed stems was significantly higher in CBL than in QC, probably reflecting the higher density of overwintering deer in CBL. In CBL red maple was browsed more than aspen. In QC red oak was browsed more than red maple and witch hazel, which were both browsed equally.

Since the type of forest is very different between the two study areas, it is not surprising that browse availability also differed between them. Recent research suggests that winter food sources other than browse – such as litterfall (lichens and branches) – may also be important. As litterfall is more abundant in unharvested areas, it appears essential to maintain these areas.

We used results published elsewhere to determine the potential energy and protein content of woody stems, and converted this to the number of deer the area is capable of supporting. We suggest 11 deer per square kilometre could be supported in CBL during a typical yarding period. However, this figure is a maximum that would be reduced by poor accessibility, high deer densities, or prolonged severe winter weather.

1.7 Habitat Use Analysis and Estimate of Suitable Winter Habitat Requirements

Effective wildlife management depends on a good understanding of animal habitat selection, as well as the ability to predict habitat needs. The first step involves observation of a species in its natural habitat, and surveying the biological components of that habitat in detail. The next step involves studying the relationship between the biological data and the physical attributes of the habitat. Advances in technology – notably the development of Geographic Information Systems (GIS) – have greatly enhanced our ability to undertake this second stage.

Much previous research has been dedicated to showing how deer in the northern part of their range seek out overwintering areas (yarding behaviour, section 1.5) We sought to complement this research by developing statistical models that identify preferred wintering areas. Using GIS we were able to overlay the locations of radio-collared deer collected during three winter seasons on detailed habitat maps. This provided us with a visual representation of real scenarios.

We then applied these models to the study areas to predict where deer were likely to be found. When verified, we hope our results will enable wildlife managers to predict suitable winter habitat for deer, thus allowing the province's silviculture demands to be met as well as maintaining critical deer winter habitat.

We located radio-collared deer several times during each 24 hour period to ensure that locations were representative of the animals' 24 hour routine. For QC, 998 usable winter locations were obtained using 18 deer, and for CBL, 617 locations were obtained from 33 deer.

Vegetative sampling

Based on telemetry locations, browse data, and ground and aerial surveys, we constructed a map of overwintering *deer concentration sites* (DCs). We also selected and mapped seemingly suitable stands of comparable cover-type, height, and age that exhibited little or no use by deer to represent *no deer concentration sites* (NDCs). One DC site and one NDC site, each of about 100 hectares, were selected within each study area for intensive vegetative sampling. We took measurements of several characteristics of the overstory, including total number of stems, number of trees by species, and stand age and height. In the understory we sampled a total of 16 variables, including presence of deer pellets or browse, distribution of moss, and total number of shrub species in three levels of understory.
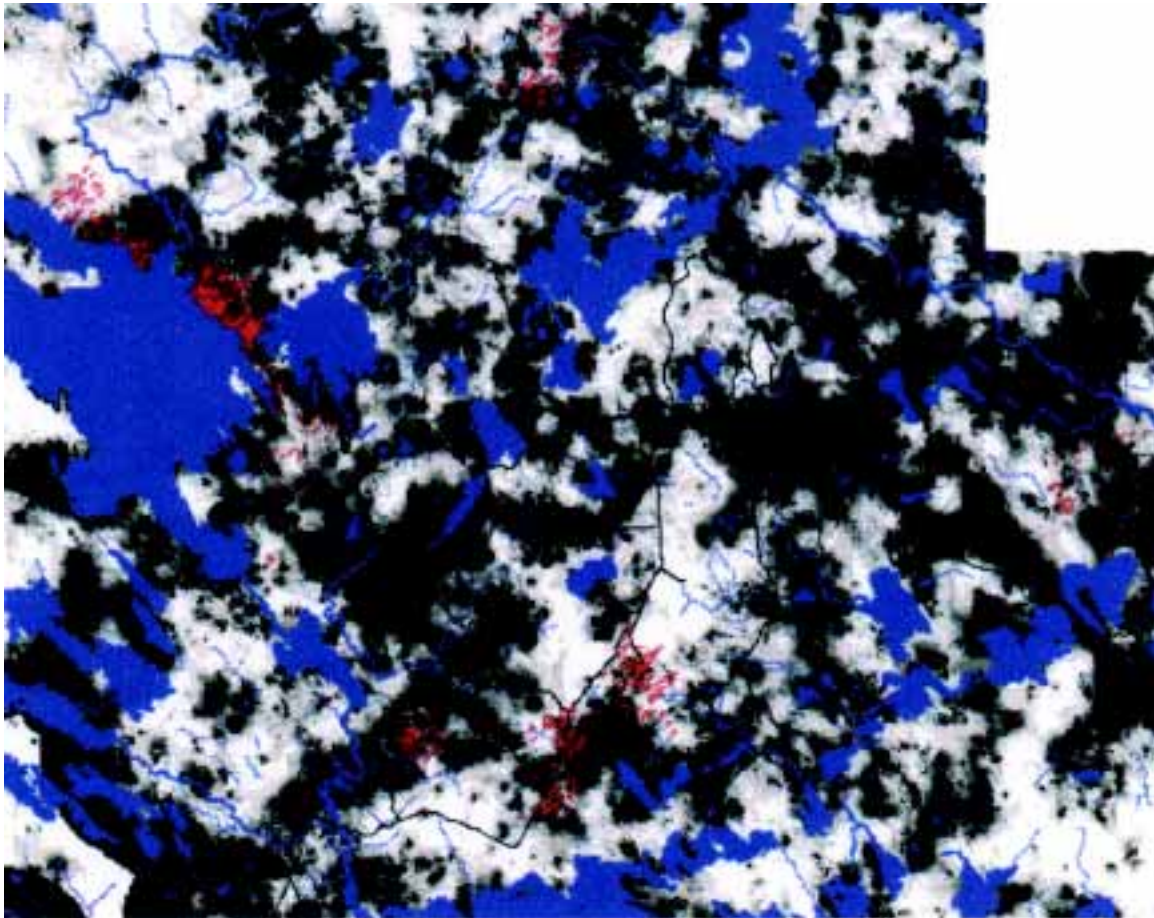
From this data we generated maps showing the probability of deer being present in all parts of both study areas. The accuracy of the model generated was then tested by comparing it to actual deer locations not used in the development of the model.

Figure 4
Probability of deer occurrence in CB.
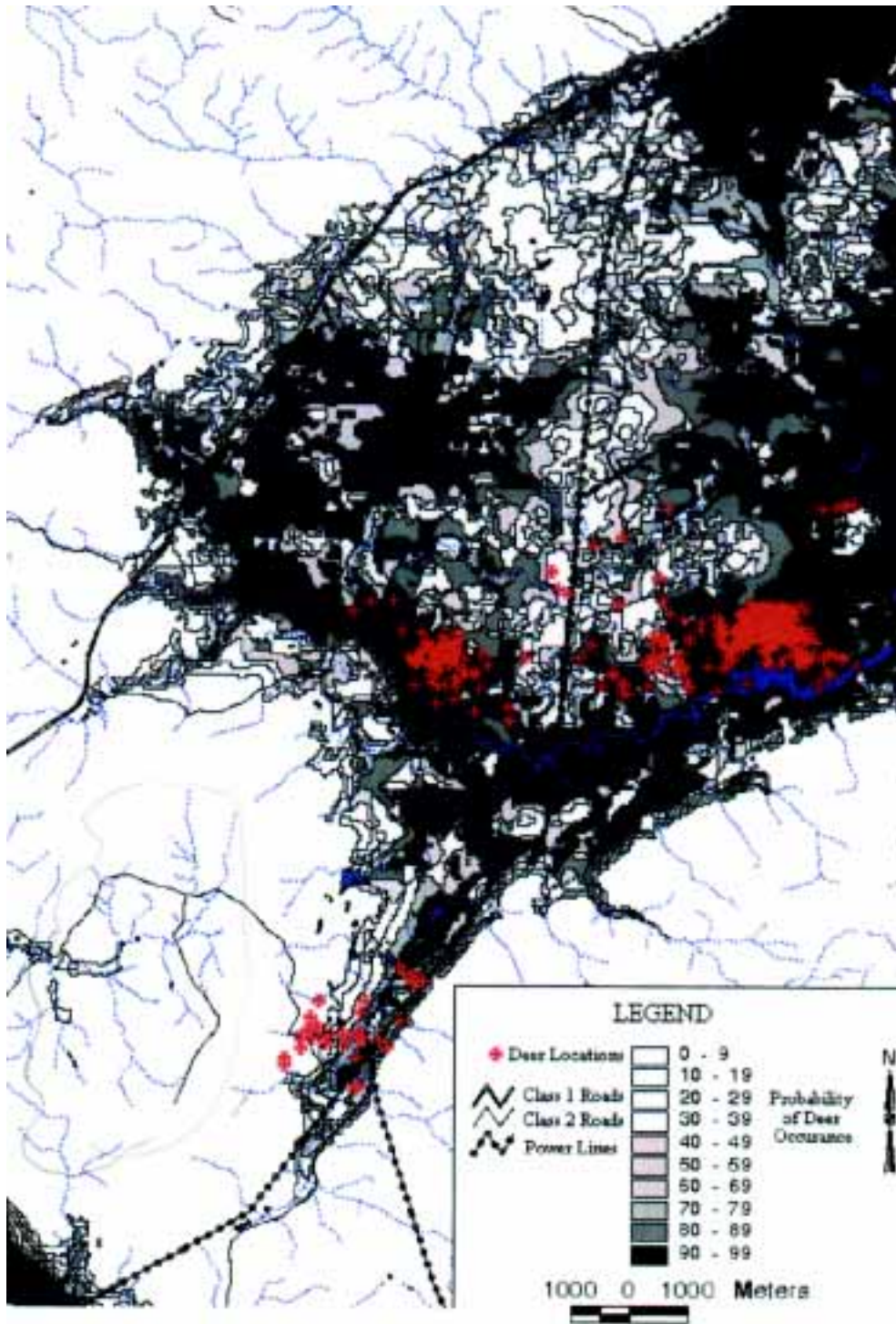
Figure 5
Probability of deer occurrence in QC.

LEGEND

Preferred deer wintering areas

The models we developed consist of a set of equations. Overall, it appears that deer in CB prefer low elevations (because higher elevations are colder, receive more snow, and have longer winters); high site quality (larger overstory trees and diverse and plentiful understory vegetation); absence of a second story under the main canopy (typically made up of regeneration 2 to 4 m in height intertwined with fallen dead wood – this provides very little warmth or forage for the animals, and may impede deer movement); and proximity to, or interspersion with high coniferous canopy (for cover). They tend to avoid northerly slopes.

By comparison, deer in QC seem to select areas of diverse cover type with easterly exposure and 10 to 20 per cent slope. They are less influenced by proximity of stands with a high percentage of coniferous crown closure. Interestingly, they were not affected by an increasing distance to clearcuts or partial cut edges (which are prime deer feeding areas). This is understandable in light of the relatively mild winters in southern Nova Scotia, which mean that the animals have more energy to forage further afield.

Our models proved to be very precise, accurately identifying 26 per cent of the Cape Breton Lowlands and 44 per cent of Queens County as areas with a high probability of deer occurrence. We believe that this represents a significant improvement over past wildlife models.

1.8 Deer Physical Condition and Relationships with Habitat

Understanding the relationships between winter habitat, deer population density, survival, and overall fitness is one of the central aims of this report. Here we attempt to find the relationship between age specific fertility, survival, and overall deer fitness to winter severity and population density, and make recommendations for assigning optimal population goals for deer herds.

Urinalysis

The analysis of urine-soaked snow from free-ranging deer can be used to assess the animals' physical condition. We collected urine samples in both study areas during six two-week periods in the winter of 1995. Unfortunately, there was very little snowfall that winter, resulting in low sample sizes. Each sample was analyzed for the presence of urea nitrogen, creatinine, potassium, and sodium.

Based on analysis of these samples, it seems that deer in QC were more nutritionally stressed than deer in CB. However, it appears that any differences between the mean condition of deer in QC and those in the Eden DWA were minor.

Malnutrition and age-specific fertility in relation to winter severity and deer density

We analyzed estimates of winter deer density, sex, age, age specific fertility, physical condition, and winter and spring severity collected by DNR staff between 1983 and 1997. They estimated deer density from pellet group surveys. DNR staff also collect deer carcasses (mostly road-killed) year-round, from which they estimate age from tooth wear and eruption. All female deer carcasses found between February 1 and the middle of May (between 100 and 300 each year) are checked for the presence, number, and sex of fetuses. The amount of fat in the femur bone was estimated visually as an indicator of physical condition. Winter severity (based on snowfall and temperature) and spring severity (based on rainfall and temperature) were calculated for winters between 1983 and 1995.

The proportion of individuals in the population with low levels of femur bone fat was not related to winter severity, but to high winter population density. It appears that at moderate to high deer densities, food competition during winter in Nova Scotia can be substantial. There may be a lag in the recovery of vegetation after severe browsing by deer because, during the mid-1990s, a substantial portion of Nova Scotia's deer herd continued to experience malnutrition during winter despite low deer densities and mild winter conditions. This also indicates that Nova Scotia's winter carrying capacity is low.

Although other food sources (such as litterfall) may be significant, it appears likely that – under current conditions – overwintering herds in excess of 70,000–80,000 deer will probably exhibit reduced fertility and physical condition owing to food competition. If overbrowsing or sub-optimal forest management has affected deer habitat quality in the past, carrying capacity for deer in Nova Scotia may increase in the future as the browse recovers, and forest management becomes more ecologically aware.

Winter mortality

Other researchers have estimated winter mortality in southern New Brunswick at an average of 5.7 per cent between 1988 and 1996. Given the climatic similarities between southern New Brunswick and Nova Scotia, it is apparent that during most years winter-kill (other than predation) may not be a significant mortality factor throughout most of Nova Scotia.

Estimates of fawn survival to the age of nine months in our study ranged from 40–85 per cent. Coyote predation is a major factor affecting fawn survival (section 2.3), and cold, wet spring weather can also influence survival during the first few weeks of life.

Fertility

Age specific fertility data was quite variable, however fertility in both yearlings and adults was most closely related to winter density three years prior. Therefore, during the increase in deer numbers from 1982 to 1985, the fertility of deer in Nova Scotia decreased annually, and continued to decline for four years following the population peak of 1986. Such a time lag is probably due to the slow recovery of over-browsed vegetation.

Population goals

Maximum sustained yield for northern deer herds is usually achieved at densities of about 55 per cent of summer carrying capacity. However, it is often difficult to convince the public and wildlife managers that sustainable harvests actually decline for deer populations exceeding this figure. Summer range quality has a major effect on antler development in bucks, therefore yearling antler beam diameters can be used as a reliable indicator of deer population relative to summer carrying capacity. In general, we suggest that the herd should be held below 40 per cent of summer carrying capacity, the point above which breeding in fawns often ceases. This is equivalent to a mean yearling antler beam diameter of approximately 16 mm.

Section 2

Aspects of The Ecology of The Eastern Coyote in Nova Scotia

2.1 Coyote Social Organization and Spatial Distribution

For most medium to large-sized carnivores, distribution and abundance of food is probably the single most important factor influencing distribution and social structure. The social structure of the eastern coyote seems to revolve around resident adult pairs and their offspring. These family groups maintain non-overlapping but adjoining home ranges of between 30 and 50 square kilometres – two to three times larger than their western counterparts. Solitary, transient coyotes may live on large areas encompassing parts of several different coyote territories. They almost always travel alone, and do not breed unless a vacant territory can be found. Winter packs of coyotes generally consist of adult pairs with young coyotes that have not dispersed, and are typically made up of three or four animals.

White-tailed deer and snowshoe hare are the staple food items of the eastern coyote. It has been suggested that the larger home range size of the eastern coyote is a result of decreased prey diversity and abundance throughout much of the northeast. However, there is no consensus as to how the size of areas used by coyotes varies with prey abundance.

In many areas of the northeast, deer migrate seasonally into wintering areas. As a result, some coyote territories have access to a large number of deer, yet others contain few or none during the winter months. Under such conditions, coyotes may trespass into neighbouring territories. However, the effects of varying densities of deer and hare on the social and feeding ecology of coyotes in the northeast remains largely unknown.

Monitoring coyotes

We captured 51 coyotes – representing 14 different family groups and 12 transient or dispersing individuals – and fitted them with radio-collars. Coyotes were classified as breeding residents, resident associates, juveniles (offspring of that year), or transients. They were primarily monitored from the ground using triangulation, however a helicopter was used when they could not be found from the ground. Most radio-collared coyotes were relocated five times a week from December to March, and twice a week from May to November. More than 3500 relocations were collected. These showed that coyotes in both study areas were territorial. We were able to clearly define twenty-four annual territories (Figures 6 and 7), which were significantly larger in QC than in CB.
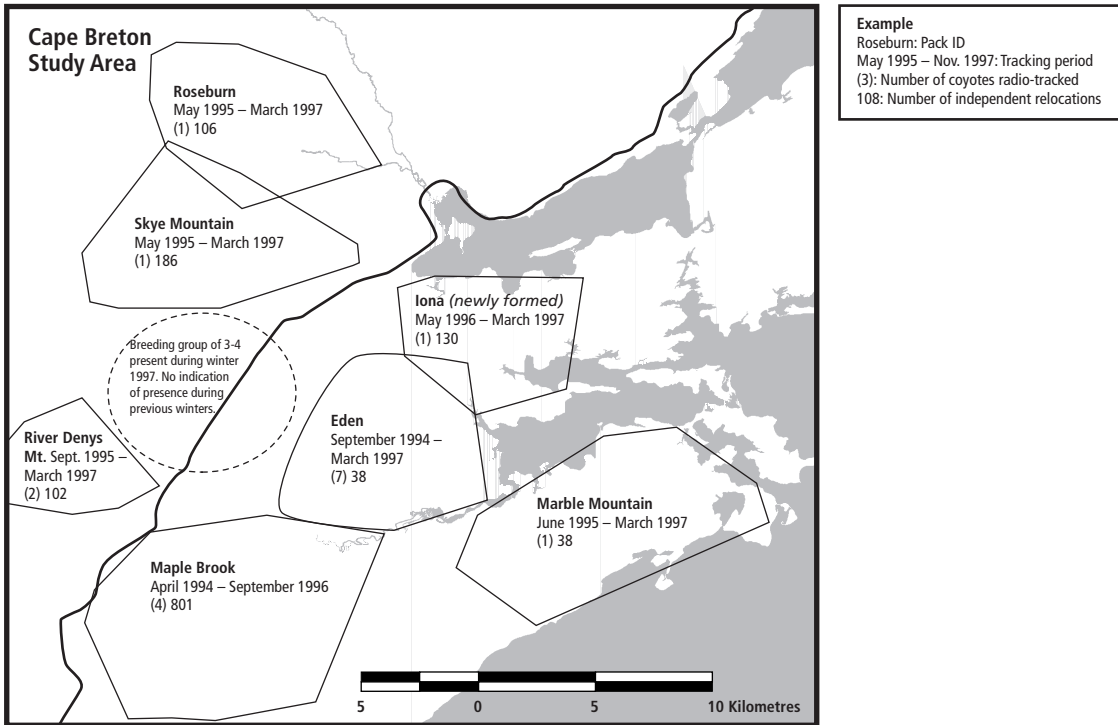
Group formation and cohesion

Sociality in coyotes is a strategy that allows them to hunt larger prey while preserving the advantages that smaller body size gives in being able to hunt small prey. Pup survival may also be increased through group assistance in feeding and rearing.

Until now we did not know whether coyotes form groups as a direct response to the presence of larger prey, or if larger prey merely strengthen cohesion of groups formed for other reasons. If groups are formed primarily to exploit large prey, we should expect to find smaller, less-cohesive groups using smaller prey as a primary food source.

We found that group formation and cohesion was not limited to packs that used deer – rather than snowshoe hare – as their main winter food source.

Figure 6
Distribution of coyotes in CB.

Figure 7
Distribution of coyotes in QC.
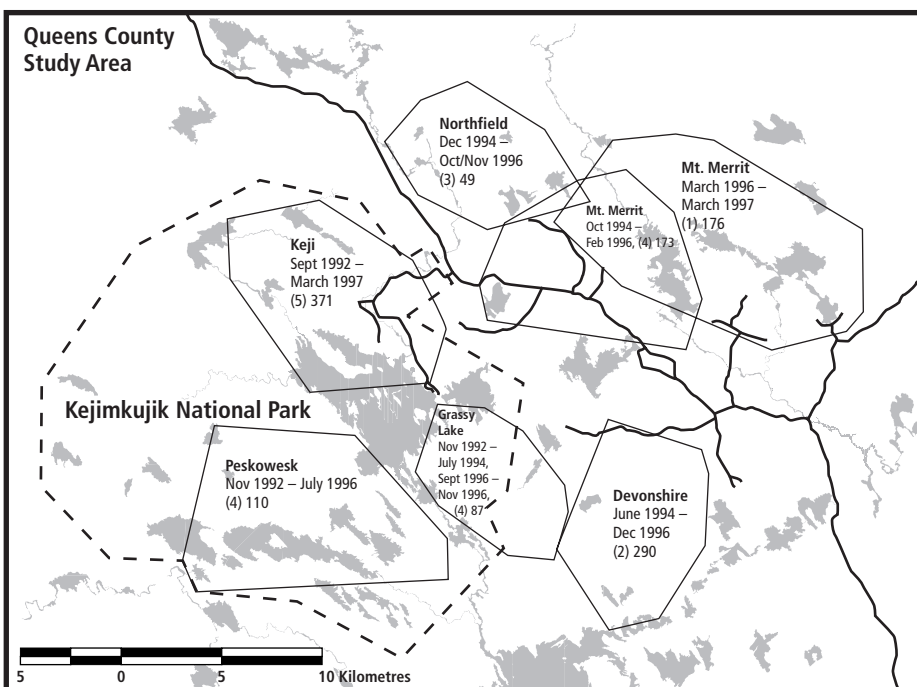
This suggests that cooperative foraging (hunting as a pack) is not the main factor driving group formation and cohesion, but merely an additional benefit. We believe that territoriality and group formation by eastern coyotes improves the survival of pups and juveniles prior to dispersal. We are not aware of any non-territorial eastern coyotes raising pups. We also believe the reason solitary coyotes (transients) do not maintain territories is because territories are not necessary for non-breeding coyotes, not because they are unable to defend a territory against pairs or groups.

Prey distribution and abundance
We determined the relative abundance of white-tailed deer within each study area using pellet group counts. Hare pellets were also counted. An aerial survey was conducted in mid-February 1997 to provide further information on the relative winter distribution and abundance of deer in CB, and to define the limits of the Eden DWA. From 1995–97, observations from many less formal aerial surveys during January to March also provided information. Ground surveys conducted along a trail network passing through all spring-fall coyote territories following fresh snowfalls from December to March 1996–97 provided data on the distribution of both deer and coyotes.

Estimates of deer and hare densities were consistently higher in CB than in QC. Overall the hare densities were high in CBH, with only a few scattered pockets of deer being present during the winter. CBL contained moderate hare densities and relatively higher deer densities year round. QC was typified by considerably lower, more uniform densities of both deer and hare all year .

Except for temporary excursions, coyotes used the same general territory areas during winter and summer, and from year to year, although the average size of winter areas was larger than that of summer areas. Although food is generally most restricted for coyotes in the summer, the presence of immobile pups at this time probably limits movements. Extended movements during winter may also result from an increase in the need to defend and mark territories during the breeding season.

Coyote–deer spatial relations
Overall we found that coyotes did not use areas of higher deer density any more than other areas within their territories. In fact coyotes in CBL (excluding the Eden DWA) used areas containing few or no deer more than expected. This may be related to the higher vulnerability of deer in low density areas (section 2.3)

Territories were generally very stable, and at least two maintained the same approximate boundaries throughout the five years of our study. In QC we noted one confirmed territory shift, which may have been related to prey availability. In CB we did not record any shifts in the area used by entire breeding groups.

Coyotes in CBH made more excursions outside their territories than those in CBL. Most excursions took place in the summer in both study areas, which suggests that prey availability may have been a significant factor, as this is the time when food is most restricted for eastern coyotes. In CB coyotes generally travelled to areas of higher deer density, often trespassing into neighbouring territories. Although coyotes in CBH had access to the highest hare densities, they made the most frequent excursions during winter. This may be related to the need for a higher fat diet during pregnancy – snowshoe hare is relatively low in fat compared to white-tailed deer. This theory is supported by the fact that coyotes in CBL and QC, which had access to deer all year round, made relatively few excursions during winter.

Excursions were generally less than 10 km, and rarely lasted more than three days. The short duration is probably related to the risk of aggressive encounters while trespassing, and of losing a territory to other coyotes while absent. Territorial behaviour may prevent coyotes from concentrating in DWAs, and may keep the ratio of coyotes to deer relatively low.

Survival, reproduction, and dispersal
We recorded the deaths of 32 radio-collared coyotes during this study, the majority between October and April. Twenty-nine of these were the result of human activities (14 snared, 10 shot, 3 car collisions, and 2 trapped), one coyote was killed by other coyotes, one died of infection, and one from unknown causes. None died within Kejimkujik National Park.

Packs in CB reared pups successfully in 83 per cent of attempts, compared to 78 per cent in QC. Failures were due to human exploitation (killing of breeding females) in CB, and to malnutrition and the old age of a breeding female in QC.

Packs are formed primarily as a result of delayed dispersal of juvenile coyotes. Most juvenile coyotes in our study had dispersed by the end of their first winter. Dispersal distances averaged 53 km in CB, and 39.6 km in QC. We observed two instances of delayed dispersal in QC and one in CB. In all three cases, the juveniles maintained an association with the breeding pair and appeared to assist in pup rearing prior to their departure.

Coyote densities
Estimates of mid-winter coyote densities changed markedly during the course of our study. The size of packs were halved in QC from 1993–97, whereas there was a substantial increase in density in CB during 1996–97 (the only period when estimates were made for that area). We suggest that prey abundance and human harvest were primarily responsible.

In QC coyote numbers continued to decline following the deer population crash of the late 1980s and early 1990s. Low prey abundance (deer numbers), mild winters (low deer vulnerability), and increased coyote harvests probably all contributed to the decline. In CB rapidly increasing hare numbers and some reduction in deer harvesting appear to be responsible for the recent increase.

The potential influence of human harvest on coyote population dynamics remains unclear. The overall reproductive success of coyotes is high, and current harvesting levels are unlikely to cause significant population declines. When breeding adults are killed, they are nearly always replaced very quickly – probably from remote areas or reserves. We estimate that during the year of highest provincial coyote harvest, 1994–95, only 25 per cent of the provincial population was removed. Intense harvests during years when coyote numbers are already declining may be more effective in reducing coyote numbers. Since coyote predation on deer is most serious when deer numbers are already low, localized coyote control efforts at these times may enhance deer survival in some areas.

2.2 Coyote Movements and Activity Patterns

Most studies of coyote activity have concluded that coyotes are largely nocturnal, although others report little difference in coyote activity with respect to time of day. Activity patterns of eastern coyotes remain poorly described, and the effects of decreased prey availability and diversity throughout much of the northeast remain unknown. We tried to determine the daily distances travelled by coyotes in Nova Scotia, to describe coyote activity patterns in relation to season and reproductive status, and to determine the amount of time spent active and resting.

We monitored coyotes both opportunistically and during intensive monitoring sessions, relocating radio-collared animals using standard methods of triangulation. Their daily activity patterns were determined by pooling all observations in each of five time periods: early morning, late morning, afternoon, early evening, and night. We estimated coyote movements by summing the total distance traveled between successive locations. We also compared daily distances traveled, and the mean duration of activity and resting periods.

Daily and seasonal activity patterns

Based on 1400 records, we found that coyotes spend approximately the same amount of time resting and active, with several periods of rest and activity interspersed throughout the day and night. However, they were generally most active at dusk and least active during late morning. Coyotes were more active during summer than winter.

Most previous studies that show coyotes to be mainly nocturnal were conducted in areas of intensive agriculture or other human development. We suspect that activity throughout the day is typical of undisturbed coyote populations, particularly in areas providing abundant forest cover, such as Nova Scotia.

Increased activity levels near daybreak and dusk may be related to hunting, as they correspond roughly with the activity patterns shown by snowshoe hare and white-tailed deer. Yet, coyotes elsewhere hunt for deer near midday during winter, possibly because it is easier to catch deer that are sleeping than to catch those that are active. We agree with other researchers that coyote activity patterns are linked to those of their prey.

Daily movements

Coyotes traveled an annual average of 20.2 km every 24 hours. Breeding males travelled the greatest distances of all, during the pup rearing season, although they were reluctant to forage more than 5 km from the den. At this time they traveled significantly further than breeding females during the same period, further than all coyotes during winter, and further than non-breeding coyotes during summer. All coyotes traveled their least distances during winter.

Coyotes travelled shorter daily distances during the pair formation and breeding season (winter) than at all other times of year, so mate seeking was probably not a significant influence on movements during this study. We suggest that these decreased movements during winter were related to increased vulnerability of major prey (deer and hare).

2.3 Coyote Food Habits and Predation on White-tailed Deer

There has been widespread public speculation that predation by the eastern coyote is an important factor in the prolonged suppression of deer numbers in Nova Scotia. Some studies suggest that coyote predation does indeed limit deer densities. Our purpose here was to determine the extent and significance of coyote predation as a mortality factor for deer in Nova Scotia. The term *killing rate* refers strictly to the number of deer killed; *predation rates* also take predator and prey densities into account.

Seasonal food habits

We determined the seasonal food habits of coyotes primarily from scat (droppings) analysis. Scats were collected systematically along the trails and roadways of each study area during all months of the year, and their contents identified as to species. Winter feeding habits were also determined more directly through snowtracking. Where possible, a jawbone and femur were collected from any coyote-killed or scavenged deer discovered, to provide information on age (from tooth wear and development), and on physical condition (from bone marrow fat content).

Coyotes consumed at least 35 different prey species: 18 wild mammals, 3 reptiles, 1 amphibian, 4 birds, domestic livestock, cats, dogs, 6 types of wild berry, and other vegetation. Diet was most restricted during the winter, reflecting seasonal changes in the availability and abundance of common food items.

Together, deer and hare comprised the majority of scat content (66–81 per cent), although small mammals and fruits were important food items from late summer to early fall. In QC the use of deer was highest between December and May, and lowest during late summer. In CB the use of deer was highest during June and July and lowest during spring and fall.

In QC the use of deer declined and hare increased in early 1995. Prey densities changed only slightly at this time, but there was much more snow accumulation during the winters of 1993 and 1994 than in 1995–97.

Fawns composed a significant part of the diet of coyotes during the summer. Indeed, consumption of fawns exceeded that of hare in all areas in June and July, despite very high densities of hare in CBH. Most fawns were killed rather than scavenged.

Fruit as a potential food buffer

In both study areas, the use of fruits declined as hare and deer densities increased, although wildberries remained readily available. Although wildberries have a high calorific content, they are only about 50 per cent as digestible as mammalian prey. High fruit use appeared to be associated with decreased availability of prey, and probably did little to buffer predation on deer or hare.

Estimation of predation rates on deer

We estimated total deer losses to coyotes by calculating the energy requirements of the coyote populations in each study area and then converting this into "deer equivalents." We also determined the proportions of adult deer and fawns ingested by coyotes from scat analysis.

All coyote packs in this study killed deer during winter. Winter killing rates averaged between 2.8 and 6.2 deer by each pack every 100 days. These rates appear to be influenced more by winter severity and the availability of snowshoe hare than by pack size. However, single coyotes may kill a significant number of deer (section 2.4), so it may be inappropriate to estimate winter predation rates based solely on deer killed by breeding groups.

Carcasses of 102 deer were consumed by coyotes during the winter periods. Sixty nine were victims of predation, the remainder died of other causes and were scavenged. Fawns were over-represented in the sample of coyote-killed deer we examined in QC during 1992-94, and under-represented there during 1995-97. Deep snow may have increased

their vulnerability during the winters of 1993 and 1994, but we do not know why they were under-represented subsequently. We found no evidence that deer eight years old or more when killed were disadvantaged by their age.

In general, bone marrow fat reserves of deer killed by coyotes appeared to be as good or better than those of road-killed deer in each study area. Overall, we conclude that the majority of deer killed by coyotes were prime-aged, and were not suffering from severe malnutrition.

Estimates of annual predation rates in QC declined from 20.5 per cent in 1992 to 8.1 per cent in 1997. In CB they remained at about 10 per cent between 1995 and 1997. Predation on fawns accounted for a large portion of the total estimates during summer, but predation on adult deer was substantial in QC from 1993–95. High use of fawns by coyotes in QC suggests that summer predation may have had a substantial limiting effect on deer populations. We estimated predation rates on deer fawns by other predators, such as bobcat, lynx, and black bears at 10 per cent in QC and 5 per cent in CB. Figure 8 summarizes the birth and death rates for deer throughout the study.

The low availability of alternate prey, low deer densities, and unusually severe winter conditions were probably responsible for the high predation observed in QC during 1992–93.

Figure 8

Estimated mortality factors (expressed as percentages) for white-tailed deer in the Queens County (QC) study area, June 1992 – May 1993, June 1995 – May 1996, and June 1996 – May 1997; and the Cape Breton study area (CB), June 1995 – May 1996, and June 1996 – May 1997.

	QC 1992	QC 1995	QC 1996	CB 1995	CB 1996
Registered harvest					
Males >l yr. old	42.6[1]	25	25	20	20
Antlerless deer	25[1]	0	0	0	0
Unregistered harvest					
Males > l yr. old	15	15	15	5	5
Antlerless deer[1]	5	13	13	7	7
Winter kill					
Males >l yr. old	5	3	3	8	8
Females >1 yr. old	3	3	3	3	3
Fawns	10	5	5	10	10
Coyote Predation[2]					
Adults	12.7	8.3	5.2	6.1	6.8
Fawns	31.6	26.8	12.1	14.6	l5.5
Other Predators[3]					
Adults	7.9	5.7	3	1.5	2
Fawns	10	10	10	5	5
Other mortality[4]					
Fawns	5	5	5	5	5
Adults	3	3	3	3	3
Recruitment (%)[5]	l5	22.8	34.8	28.5	30.5
Growth Rate[6]	.67	.93	1.08	1.04	1.06
Comments	Continued to decline until winter 1996, currently increasing.			Population increasing at close to predicted rate.	

1 Harvest rates for this period were calculated based on regional population estimates and registered harvest (NSDNR, unpublished data). Harvest rates (registered and unregistered) for other periods are based on radio-telemetry data.

2 Estimated rates for adults are based on the average of rates predicted from radio-telemetry and scat analysis. Since limited telemetry data was available for fawns, predation rates on fawns are based on scat analysis.

3 Four of 15 radio-collared deer killed by predators were killed by either bobcats or lynx so we estimated this predation rate on adult deer as (.267) x (predation rate attributable to coyotes). Predation rate on fawns by predators other than coyotes was estimated crudely from the literature (see text).

4 Includes deaths attributable to vehicle collisions, old age, and natural accidents or sickness.

5 Calculated as the total number of fawns surviving to l year divided by the total number of deer alive immediately prior to the birth of this fawn cohort.

Coyote response to changes in prey density, and evidence of prey switching

The number of prey consumed by a predator varies with the density of its prey. We examined how the relative densities of deer and hare affect the number of each prey type consumed per coyote within each territory during winter. We also examined the influence of deer and hare densities on deer consumption during June and July, when predation on fawns is greatest. As it should be easier for coyotes to capture hare than deer, we hypothesized that coyotes would eat more deer than hare when deer were more abundant than hare, and switch to hare as they became more plentiful.

During winter, the number of deer consumed per coyote increased when the density of deer was high, and when hare density was low. The number of hare consumed per coyote increased as hare density increased, but did not alter in relation to changes in deer density. Although the use of hare increased in winter and the taking of deer decreased significantly as hare density increased, coyotes showed a higher preference for deer than hare at high hare densities and /or low deer densities than would be expected from our hypothesis.

During June and July, the number of hare consumed per coyote increased significantly as hare became more abundant. At this time the number of fawns consumed per coyote may have decreased as hare abundance increased, but did not change with deer density. Our results suggest an overall preference for fawns over hare in June and July.

The eastern coyote has been described as a generalist predator, and generalists are expected to feed non-selectively. In areas where both deer and hare were readily available, coyotes fed predominantly on hare, and the use of deer declined as hare density increased. However, we could not identify a traditional switch in prey selection in relation to the relative abundance of each prey species. Our data support the conclusion that – although coyotes should be considered generalist feeders – they prefer to feed on deer (when available) rather than hare, presumably because it is more profitable.

Coyotes in CBH appeared to be satiated on hare during winter, and hare may have provided sufficient energy for coyotes to pursue larger prey, namely deer. We suspect that during most winters, coyotes in QC are forced to focus their hunting efforts on hare and other small mammals, despite low hare densities, due to low vulnerability of deer. However, when winter conditions are severe, coyotes switch to feeding mainly on deer.

Management implications

Our study reveals the importance of legal harvest as a tool for managing deer populations. It is important to prevent populations from erupting, as the subsequent crashes are nearly impossible to prevent. But continued high harvests following a peak in deer numbers may accelerate and prolong the subsequent decline in numbers. It is unlikely that managers can prevent excessive coyote predation under certain conditions. At such times managers must be ready to impose rapid restrictions on the hunting of antlerless deer.

2.4 Factors Influencing Killing Rates of White-tailed Deer by Coyotes in Nova Scotia

Predation is well recognized as a major factor affecting the dynamics of north American ungulates (hoofed mammal species), but has been little studied. We sought to determine which factors affect deer killing rates by coyotes in Nova Scotia. Deer that had been killed by coyotes were located and examined as described in section 2.3. In addition, DNR staff snowtracked coyotes opportunistically during the winters of 1989–94.

Effects of coyote social group size on deer killing rates

Approximately 38 per cent of the 87 deer chases we documented were successful. Groups of three or more coyotes initiated proportionally more chases than single coyotes. The mean distance of successful chases (269 m), was not significantly less than the mean distance of unsuccessful chases (330 m).

Many authors have reported that groups of coyotes are more successful at killing large prey, and that solitary coyotes are more apt to scavenge large carcasses and kill smaller prey. Contrary to our expectations, the success of chases did not vary with group size, although larger groups were more reluctant to give up a chase – perhaps due to a greater expectation of success, or higher food requirements for groups as opposed to solitary animals. Single coyotes killed at least 16 deer, which suggests that predation by solitary coyotes may be more significant than previously thought.

Effects of snow depth and density on deer killing rates

Our prediction that chases would be more successful and shorter when thick, dense snow conditions inhibited deer movements proved correct. Kills occurred significantly more often when the sinking depth of snow was more than 30 cm than when snow was shallower.

Effects of deer distribution and abundance on vulnerability to predation

We found that coyotes killed more deer in lower density areas than in higher density areas. It is more difficult for small numbers of deer to detect predators and create hard-packed trails to escape predators. We conclude that individual deer were more vulnerable to predation where their densities were low (section 2.3).

Effects of forest harvesting on deer vulnerability to coyote predation

Forest harvesting may affect coyote killing rates on deer by removing valuable cover for deer, and may cause deer to congregate around a predictable food source. We found that deer kills in both study areas took place closer to clear-cuts than expected by chance alone. Relatively deeper snows and less escape cover probably increased the vulnerability of deer to predation in these locations. Kills did not appear to take place closer than expected to stands with low crown closure.

Prey switching during winter

Deer kills increased monthly from January through March. This increased use of deer as winter progresses seems to occur despite no perceptible change in alternate prey (snowshoe hare) availability. Previous suggestions that prey switching resulted from increased travel and sociality of coyotes during the breeding season are not supported by our data. Daily movements were actually reduced during winter, and breeding pairs are very stable throughout the winter. In fact family groups are generally largest during early winter – before prey switching occurs.

We conclude that eastern coyotes do exhibit prey switching, and that switching may be influenced by changes in prey diversity, abundance, and vulnerability. In areas where deer and hare are the principal prey items, we suggest that predation on deer may increase sharply with increased snow depths, or when hare and/or deer numbers decline.

2.5 Winter Condition of Coyotes in Relation to Prey Density

Several researchers have noted that eastern coyotes are typically emaciated during early summer, whereas carcasses collected during winter generally have moderate fat reserves. This suggests that it may be easier for coyotes to obtain adequate food during winter than at other times of year. Yet few studies have attempted to relate relative nutritional condition of coyotes to the abundance of major prey species.

Urinalysis
The analysis of urine collected from snow can be used to compare the nutritional status of free-ranging animal species during winter – research with wolves has shown that the ratio of urea to creatinine in urine samples is generally lower in starved animals than in those that are well fed.

We used urinalysis to compare the relative nutritional condition of coyote family groups living in territories containing different densities of white-tailed deer and snowshoe hare. Coyote urine samples were collected opportunistically while snowtracking radio-collared coyotes between January and March, 1996 and 1997. We analyzed 525 samples for urea and creatinine using spectrophotometry.

Overall we found that coyotes were in better nutritional condition in CBH than in QC. Coyote packs that fed primarily on snowshoe hare during winter were in better condition than packs using both deer and hare as major food sources. We believe this is because coyotes are able to feed more frequently when taking smaller prey, although it may be an artefact introduced by our sampling procedures. Coyote condition did not change significantly as winter progressed, but did worsen in January and February (the peak time of breeding) in both QC and CBL. However, coyotes remained consistently in good condition in CBH.

Deer density exerted little influence on coyote condition, probably because deer vulnerability rather than just abundance was more closely related to the ability of coyotes to kill or scavenge deer. Although there was little difference in the rate at which groups of two to four coyotes killed deer, increasing coyote travelling group size may have had a positive effect on coyote nutritional condition during winter. Larger packs using deer as a major food source may do so more efficiently than smaller packs because of less loss to scavengers

Management implications
Although there is no baseline data from coyotes yet, we suggest that urinalysis can be used to measure the relative fitness of coyotes occupying different areas during winter. However, sampling is labour intensive, and the technique will probably remain largely restricted to situations where samples can be collected in adjunct with other research activities.

Section 3

Conclusion: Managing Deer, Coyotes, and Forestry in Nova Scotia

3.1 Deer

Deer numbers in Nova Scotia have seldom remained stable for more than a few years at a time since the 1930s. We have demonstrated that – under certain conditions – predation, harvest, food competition, and winter severity can severely affect the growth of deer populations. Carrying capacity for deer in Nova Scotia during winter appears to be lower than in other areas of the northeast, and care must be taken to prevent another major decline in deer numbers.

Temporary over-populations of deer that occurred in the past were in no way sustainable under typical winter conditions. An overabundant deer population may be followed by a prolonged decline in deer numbers. Recent improvements in deer management in the province – such as zone based allocation of antlerless permits, which are issued in accordance with the need to reduce the density of deer – should allow managers to respond quickly and adequately to expected changes in the growth of deer populations. Biologically, there is no longer an excuse for such a serious and lengthy decline in deer numbers as occurred province-wide during the last decade.

3.2 Coyotes

There appears to be little we can do to prevent coyote predation from occurring other than supplying deer with optimal winter habitat to improve their physical condition and enhance the probability of avoiding predators. In general, we expect the effects of predation to be most serious when deer numbers are declining or low.

3.3 Forestry

We believe that the maintenance of quality DWAs is important for several reasons, in particular:

1 Deer living in low deer density areas were more vulnerable to winter predation than deer living in wintering areas (this was particularly evident in CB).

2 Wintering areas appear to serve a summer area more than 10 times their size. The use of wintering areas is highly traditional, so the success of deer overwintering in any area has an effect on a much greater surrounding area. Over time, even a slight improvement in winter survival will result in an increased number of deer using the area.

There is little doubt that extensive clear cutting has decimated many DWAs. However, guidelines are now in place that limit harvesting in and around these areas. In Nova Scotia, no single clear-cut in any area designated a DWA should exceed 10 ha. Quality DWAs enhance deer survival during winter, even though they will have to support some forest harvesting when managed.

We believe that DWAs should be managed on a larger scale, so there is always an adequate mix of food and cover within their boundaries, as deer are unlikely to relocate to another wintering area. If deer become numerous enough to damage their winter habitat, increased harvests should be applied throughout the summer range served by the DWA in question. In general, we believe that managing large wintering areas will be more beneficial than small, scattered winter pockets.

We suggest that controlled harvesting within areas designated as DWAs be allowed and even encouraged. *Our critical recommendation is that no area within any DWA be more than one kilometre from a stand of at least one square kilometre in size, which has more than 70 per cent canopy closure.* Excessive forest harvest can severely limit the availability of quality cover for deer, and may decrease physical condition and increase vulnerability to predation. Current standards outlined in the *Forest/Wildlife Guidelines and Standards for Nova Scotia (1989)* should meet the needs of deer.

Unfortunately, many DWAs have not been officially identified at present and thus are not managed. In addition, the guidelines are only enforceable on crown lands. Efforts should be made to enter partnerships with private landowners to ensure that DWAs on private lands are adequately managed. The planning of forest operations in and around DWAs must consider the needs of deer during severe winters, even though these are infrequent.

Successful management will require an integration of habitat and harvest management, and an ability to predict when natural conditions are likely to severely limit population size.

Managers currently have the information and tools required for biologically sound management of our deer populations. The public should be aware that compliance and cooperation with harvest regulations are necessary for successful management. Efforts should be made to encourage both the public and political support necessary to execute sound management policies.