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ABSTRACT

Field studies conducted in north-central Minnesota during 1980-1986 suggest that wolves (*Canis lupus*) killed about 6% of the white-tailed deer (*Odocoileus virginianus*) population (including fawns). Given certain assumptions, simple equations can be used to estimate sustainable numbers of deer, wolves, and hunter harvest in an area.

INTRODUCTION

In northern Minnesota, white-tailed deer are an abundant and valued big game species as well as the primary prey of wolves, a federally classified threatened species. For the purposes of these proceedings, one might consider deer to be a "harvestable crop" to which wolves cause some "damage". Given the public popularity of deer and the protected status of wolves, it is essential to identify the impact and relative importance of wolf predation on deer and develop management strategies resulting in prudent conservation of both species.

During 1980-1986, field studies concerning the population dynamics and interactions of wolves (Fuller 1989), deer (Fuller submitted), and hunters (Fuller 1988) were conducted in an area of north-central Minnesota that was fairly representative of deer range in much of the forested part of the state. I obtained independent estimates of the impacts of wolves and humans on deer and, as a result, was able to model the impact of environmental events and management practices in the future. This paper reviews some findings of these studies and promotes a simple way in which to investigate various management scenarios.

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STUDY AREA AND METHODS

Wolves, deer, and hunters were studied in and near the 839-km^2 Bearville Study Area (BSA) in northeastern Itasca County, Minnesota during 1980-1986 (Fuller 1988, 1989, submitted). Wolf food habits were estimated by examining scats collected year-round. To estimate consumption rates of deer radio-collared members of wolf packs were located up to twice a day during winter to locate deer kills. Wolf density was determined by identifying all packs in the area with the aid of radiotelemetry and adding an estimate of the proportion of lone wolves in the population to the total number of pack wolves. The number of deer per km^2 killed by wolves was calculated by multiplying per capita consumption rates by wolf density.

Alternatively, survival rates and the relative importance of various mortality factors were estimated for a sample of 143 radio-collared deer $\geq$6 months old. Annual deer density was estimated from aerial surveys in winter. The number of deer per km^2 killed by wolves was calculated by multiplying the wolf-specific mortality rate by the deer density.

RESULTS

Wolves

Recalculation of scat results to account for varying pelage:biomass ratios of prey indicated that, overall, deer provided 79-98% of biomass consumed each month; beaver (*Castor canadensis*) contributed significantly to the diet (12-19% of biomass) during April-May. During June and July, 50-

80% of deer killed were newborn fawns.

Estimated minimum kill rates during January-February averaged 1 deer/wolf every 21 days, or about 2.0 kg/wolf/day. Given the age and sex composition of kills observed in winter and calculated from scat data for summer, adult wolves consumed an estimated 11 fawn and 8 adult deer each year, including about 4.6 fawns during December-May.

Wolf density averaged 45/1,000 km^2 during early winter (November-December) and 33/1,000 km^2 during late winter (March). Given an average density of 39 wolves/1,000 km^2, wolves killed about 0.74 deer/km^2/year in the BSA ([39 x 19]/1,000), including 0.31 deer $\geq$1.0 years old/km^2/year and 0.18 fawns/km^2 during December-May.

Deer

Wolves killed an average of 3.9% of radiocollared adult ($\geq$1.0 years old) deer each year. In addition, wolves killed about 12.3% of radiomarked 0.5- to 1.0-year-old fawns during December-May; no estimate from radiotelemetry data was available on the rate at which fawns <6 months old died from wolf predation.

The average deer density on 15 January was about 6.16/km^2. By modeling demographic parameters such as age-specific fecundity, sex ratios, and mid-winter age ratios, the estimated density of deer on 1 June (mean date of parturition) was 12.68/km^2, including 6.56 deer $\geq$1.0-year-old deer/km^2 and 6.12 newborn fawns/km^2. The estimated density of fawns remaining on 1 December was about 1.9/km^2.

Estimated numbers of deer killed by wolves (density x mortality rate) were 0.26 deer $\geq$1.0 years old/km^2/year, and 0.23 fawns/km^2 during December-May.

Impact of Wolf Predation on Deer

Though no telemetry-derived estimate of wolf-caused mortality of fawns <6 months old was available, independent estimates of annual wolf kill from wolf data and deer telemetry data were similar both for adults (0.31 vs. 0.26/km^2, respectively) and for older fawns killed during December-May (0.18 vs. 0.23/km^2, respectively). This implies that the total kill estimate of 0.74 deer/km^2, based on observations of radiomarked wolves, is reasonable. Given a total deer density of 12.68/km^2 on 1 June, wolves killed about 6% of the population.

DISCUSSION

Wolf numbers in North America are directly related to ungulate numbers (Fuller 1989). Also, it is clear that deer population dynamics are related to the relative abundance of deer, wolves, and hunters. Of course, food and shelter resources or variable climatic events also can be demographically important to ungulates, but examination of deer:wolf:hunter ratios can provide initial estimates of predator-prey relationships for management purposes (Keith 1983).

The reproductive potential of deer is affected by a variety of factors, but, in general, the potential finite rate of increase for deer populations in northcentral Minnesota, given no wolf predation or hunting-related losses and adequate food, probably is about 1.30, or a 30% increase per year (Fuller 1989). Thus, wolf predation amounting to 6% of the deer population in the BSA could not, by itself, have limited deer numbers there. However, the added human-caused mortality due to hunting, illegal kill, and wounding loss did appear to limit the deer population (Fuller submitted).

Assuming food resources and weather remain fairly constant and that wolf and hunting-related deer mortality are additive, equations can be generated to explore relationships among wolves, deer and hunters (Fuller 1989). For example, the following equation estimates the maximum allowable deer harvest (*S*; kill/km^2, including illegal harvest and wounding loss), given a deer density (*D*; no./km^2), potential finite rate of increase for deer (λp), wolf density (*W*; no./1,000 km^2), and estimated wolf kill (*K*; annual kill/wolf):

$$S = D\,(\lambda p - 1) - \frac{K \times W}{1{,}000}$$

In the BSA, the harvest level required to maintain a stationary deer population, where wolf density was 39/1,000 km^2, deer density on 1 June was 6.56/km^2, wolf kill rate was 19 deer/wolf/year, and the potential rate of increase of deer was 1.30, would be about 1.23 deer/km^2. Actual harvest during this study, including illegal kill and wounding loss, was about 1.70 deer/km^2 (Fuller 1988, submitted); not surprisingly, the deer population in the BSA was declining.

The equation above can be rearranged to calculate potential wolf densities given certain deer densities and hunter harvest, or deer densities needed to support a given number of wolves and hunting pressure. Some scenarios will certainly result in nonsense values and any estimates resulting from the use of these simple equations clearly depend on the quality of input data and the validity of some specific assumptions. However, they do provide a means by which to quickly assess the potential to harvest deer in an area occupied by wolves.

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