PREDICTORS OF WHITE-TAILED DEER GRAZING INTENSITY IN FRAGMENTED DECIDUOUS FORESTS

DAVID J. AUGUSTINE [1/, 2/], Department of Fisheries and Wildlife, University of Minnesota. St. Paul, MN 55108, USA
PETER A. JORDAN, Department of Fisheries and Wildlife, University of Minnesota. St. Paul, MN 55108, USA

Abstract: White-tailed deer *(Oclocoileus virginianus)* can cause major changes in the composition and structure of forest communities by browsing shrubs and tree seedlings and grazing understory forbs. Such effects have become an increasingly pervasive management concern in protected natural areas and parks where conservation of native plant communities is a primary objective. The magnitude of these effects can vary widely according to variations in local deer numbers and availability of alternate food sources. We used measurements from 11 maple–basswood forest fragments in southcentral Minnesota to examine the predictability of deer grazing intensity on understory forbs based on local winter deer density, composition of the landscape surrounding each forest fragment, and characteristics of forb populations within the forest. In early summer, grazing intensity on 6 palatable forb species at most sites was inversely correlated with the availability of alfalfa within a 1.5-km radius of the stand (r^2 = 0.66); winter deer density and forb flowering rate within the stand were additional important predictors of grazing intensity. Later in the growing season, most variability in the intensity of grazing among forest fragments could be explained either by the availability of row crops, alfalfa, and fields within a 1.5-km radius of the stand (r^2 = 0.75) or by a combination of winter deer density and forb abundance within the stand (r^2 = 0.75). Results show that parks and preserves with low densities of palatable plant species in the forest understory may be especially susceptible to effects of deer grazing. Changes in landscape composition (e.g., increased row-cropping or conversion of land to residential developments) should be an important consideration in the management of deer densities in areas designed to protect native forest communities.

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Over the past 150 years, much of the deciduous forest region of the upper midwestern United States (Minnesota, Wisconsin, Michigan) has been converted to agriculture (Stearns 1988). Only approximately 2% of old-growth hardwood forests remain, with mostly small, scattered woodlots in the southern regions of these states (Frelich 1995). During the 1800s, white-tailed deer were extirpated in many areas, but populations recovered in the mid-1900s after the establishment of protective hunting laws (Gladfelter 1984). Today, deer populations often reach high densities in parks and preserves designed to protect remaining fragments of deciduous forest, with significant consequences for these plant communities (Alverson et al. 1988, Miller et al. 1992, Anderson and Katz 1993, Anderson 1994).

In southcentral Minnesota, some 8,000 km2 of contiguous deciduous forest dominated by sugar maple *(Acer saccharum)*, basswood *(Tilia americana)*, and elms (*Ulmus* spp.; Daubenmire 1936, Grimm 1984) were converted primarily to agricultural and residential land uses following European settlement. Only a few old-growth fragments remain, and most are <35 ha (Jakes 1980, Vasilevsky and Hackett 1980). The conservation of these remnants is a primary objective of the Minnesota Department of Natural Resources' Scientific and Natural Areas Program and private conservation organizations. Although deer in agricultural landscapes forage primarily on crops, they also consume understory forest vegetation in addition to using forest fragments for cover, parturition sites, and travel corridors (Nixon et al. 1991). Deer forage selectively on understory forbs in forest fragments during the summer and can have major effects on species characteristic of these forests such as trillium *(Trillium* spp.) in early summer (Augustine and Frelich 1998), and wood nettle *(Laportea canadensis)* and enchanter's nightshade *(Circaea lutetiana)* in mid–late summer (Augustine 1997).

[1] Present address: Biological Research Laboratories, 130 College Place, Syracuse University, SyTacuse, NY 13244, USA.
[2] E-mail: djaugust@mailbox.syr.edu

Effects of deer are hypothesized to be affected by deer density, landscape composition, and characteristics of the understory plant community. Managers typically use estimates of winter deer density in deciding whether and how often to control local deer densities. Whether winter deer density provides a useful indicator of summer grazing intensity within a given forest fragment is unknown, because deer migration and dispersal can result in significant seasonal shifts in density (Nixon et al. 1991). In addition, the availability of agricultural crops in the landscape surrounding forest fragments, and the abundance of understory forbs, may affect the amount of foraging by deer within a forest fragment. Finally, because deer selectively graze large flowering plants (Augustine and Frelich 1998), the availability of large plants in a population could affect the overall proportion grazed. We therefore examined the predictability of summer deer grazing intensity within maple–basswood forest fragments based on (1) local winter deer density, (2) composition of the landscape surrounding the forest fragment, and (3) characteristics of forb populations within the forest fragment.

STUDY AREA

We conducted surveys of understory vegetation at 11 old-growth, maple–basswood stands in Rice County (44°15'N, 93°20'W), Hennepin County (45°N, 93°30'W), and Wright County (45°10'N, 93°50'W) in southcentral Minnesota. Most sites were protected as Scientific and Natural Areas, state parks, or county parks, and 2 sites were privately owned. No 2 sites were <5 km apart, and all sites were considered independent of each other with regard to plant growth and deer herbivory during the growing season. The 11 stands were 5-32 ha in size, which is representative of the remaining old-growth fragments in southcentral Minnesota All sites contained a closed canopy dominated by sugar maple, American basswood, and elms (>50% of relative dominance by basal area), exhibited an all-aged distribution of tree sizes, and contained large (50-100 cm dbh) individuals of the 3 dominant tree species (Augustine 1997). Ironwood *(Ostrya virginiana)* was an important subcanopy species. The history of these sites since European settlement was not always known, but 2 sites experienced some historic grazing by cattle and oxen. Most other sites have not been grazed by domestic livestock. Soils were either loamy and developed from glacial deposits, or silty and developed from loess-covered glacial till (Grimm 1984). Climate is continental, cold–temperate humid, with warm summers and cold winters.

The landscape surrounding each forest fragment was a mosaic of agricultural crops, pastures and old fields, wetlands, second-growth forests, and residential developments. The predominant agricultural crops were corn, soybeans, and alfalfa.

Deer occurred at all sites but varied in density as a result of management. Deer were not hunted at 2 sites, and these had the highest densities; at other sites, deer were hunted either on a yearly or variable-year basis. Hunting is the major factor regulating deer densities. In areas with no hunting, vehicle collisions, emigration, and some poaching may be important mortality factors because no evidence of malnutrition was observed during 1994-96. Given the widespread availability of agricultural crops, high fawn pregnancy rate, and high proportion of adult does bearing twins (Harder 1980), we believe deer densities at all sites were well below ecological carrying capacity (sensu McCullough 1979). The highest deer densities occurred in winter, when deer use forest fragments for cover; deer disperse into the surrounding agricultural lands during the growing season.

METHODS

Deer Density

To examine the relation between winter deer abundance and summer grazing intensity, we used pellet-group counts to estimate winter deer density at all 11 study sites, and we used aerial counts at 6 study sites to check the pellet-count estimates. We conducted pellet counts immediately following snowmelt during 1-12 April 1996, in 45-50 50.3-m^2 circular plots at each site. We converted pellet counts to density of overwintering deer (deer/km^2) based on a 150-day deposition period and 13 pellet groups·deer^{-1}·d^{-1}.

In addition, aerial counts were conducted in January 1996 by 2 deer managers from Hennepin County Parks and the Minnesota Department of Natural Resources who have counted these sites for ≥5 years. Counts were conducted when snow cover and weather were judged by the managers to maximize accuracy. A fixed-wing Piper Supercub aircraft was used