Research Article

The Impact of White-Tailed Deer on Agricultural Landscapes in 3 National Historical Parks in Maryland

CHAD M. STEWART,[1] *Smithsonian Conservation and Research Center, 1500 Remount Road, Front Royal, VA 22630, USA*
WILLIAM J. MCSHEA,[2] *Smithsonian Conservation and Research Center, 1500 Remount Road, Front Royal, VA 22630, USA*
BRIAN P. PICCOLO,[3] *Smithsonian Conservation and Research Center, 1500 Remount Road, Front Royal, VA 22630, USA*

?1 **ABSTRACT** The legislative authorization of some United States national historical parks (NHP) includes maintaining an agricultural landscape as a management objective. This management objective can prove difficult to accomplish in some NHP given increasing white-tailed deer (*Odocoileus virginianus*) densities. Our goal was to quantify the impact of white-tailed deer foraging on agricultural landscapes in forested NHPs in Maryland, USA. We monitored 12 and 13 corn (*Zea mays*) fields at 3 NHP during the 2003 and 2004, respectively. Each field had 3 5 × 5-m fenced and unfenced plots along the edge and a similar set within the interior of the field. Within each plot we examined the number of stalks with corn, corn ear quality, and field weight prior to harvest. Fenced plots had higher weights of corn, more stalks with corn ears, and higher quality corn than unfenced plots. Estimates of silage yield based on crop weights indicate deer reduced silage yield in individual fields by 5–43% during the study period. Crop loss differed between years and fields, with plots in the Chesapeake and Ohio Canal NHPs sustaining the highest crop weight loss (28%). Eventual crop loss was correlated with proportion of corn plants browsed within 2 weeks of emergence. Some variability in loss between fields was due to landscape metrics, as fields surrounded by more forest experienced the highest loss. Our results indicate the NHP agriculture we studied receive significant deer damage to corn crops and may not be able to maintain mandated management without regulating deer numbers. (JOURNAL OF WILDLIFE MANAGEMENT 71(5):000–000; 2007)

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Several historical parks in the National Park Service (NPS) of the United States have entered into cooperative agricultural leases to maintain the landscape as it was during the historical period the park commemorates (NPS 1992), yet few of these parks actively manage wildlife. Increasing wildlife damage to agricultural crops challenges park managers and agricultural cooperators that are working to implement National Historic Park mandates of maintaining an accurate representation of a historic agricultural setting (Vecellio et al. 1994). This conflict between wildlife and agriculture may be further exacerbated within public lands that have a joint directive to maintain both wildlife and agriculture within its boundaries.

Wildlife damage to crops can at some times be severe. Corn (*Zea mays*) damage by birds in Ohio was estimated at $4–7 million from 1968 to 1979 (Dolbeer 1980). The 7 counties in Virginia receiving the highest bear (*Ursus americanus*) damage to corn lost $19.1 million annually in the mid-1980s (Virginia Agricultural Statistics Service 1986–1989, Virginia Crop Reporting Service 1985). Conover and Decker (1991) found that white-tailed deer (*Odocoileus virginianus*) were considered responsible for more corn damage than any other wildlife species. Pennsylvania farmers also considered white-tailed deer responsible for most damage to corn fields (Tzilkowski et
?2 al. 2002). Cornfields are vulnerable to deer damage from emergence through harvest (VerCauteren and Hygnstrom 1998), but any damage at the tasseling stage most directly ?3
impacts yield (Shapiro et al. 1986, Vorst 1986).

Currently deer populations in the Mid-Atlantic region exceed 40 deer per km^2 for rural and suburban NHPs (S. Bates, NPS, unpublished report). Deer densities in NHP have also increased because of the forage provided by agricultural landscapes (Hansen et al. 1997). The economic loss caused by high deer densities can diminish a farmer's incentives to participate in lease programs and frustrate resource managers attempting to achieve management goals.

The farmers who lease NHP agricultural lands are concerned about the economic losses caused by deer, yet few studies have quantified this impact (Putman and Moore 1998). Farmers are claiming corn loss in the parks examined in this study, but there is no current compensation package offered by NPS because of difficulty in estimating crop loss (J. Calzarette, NPS, and M. Frias-Sauter, NPS, personal communications). Without a method to quantify crop loss due to deer, managers face an obstacle of translating perceived loss to actual damage caused by deer (Putman and Moore 1998). Though several studies have shown that farmers can provide reliable crop-loss estimates of deer damage when sampled in large numbers (Wywialowski 1996, Tzilkowski et al. 2002), individual farmer's estimates are not as reliable (Conover and Decker 1991, Conover 1994, Tzilkowski et al. 2002).

We determined deer impacts on corn yields in 3 NHPs in Maryland. The objective of this study was to quantify the impact of white-tailed deer foraging on corn production in agricultural lands under NPS management and provide guidance to NPS staff charged with estimating crop loss.

[1] *Present address: Indiana Department of Natural Resources, 553 East Miller Drive, Bloomington, IN 47401, USA*
[2] *Corresponding author e-mail: mcsheaw@si.edu*
[3] *Present address: Michigan Department of Natural Resources, 8717 North Roscommon Road, Roscommon, MI 48653, USA*

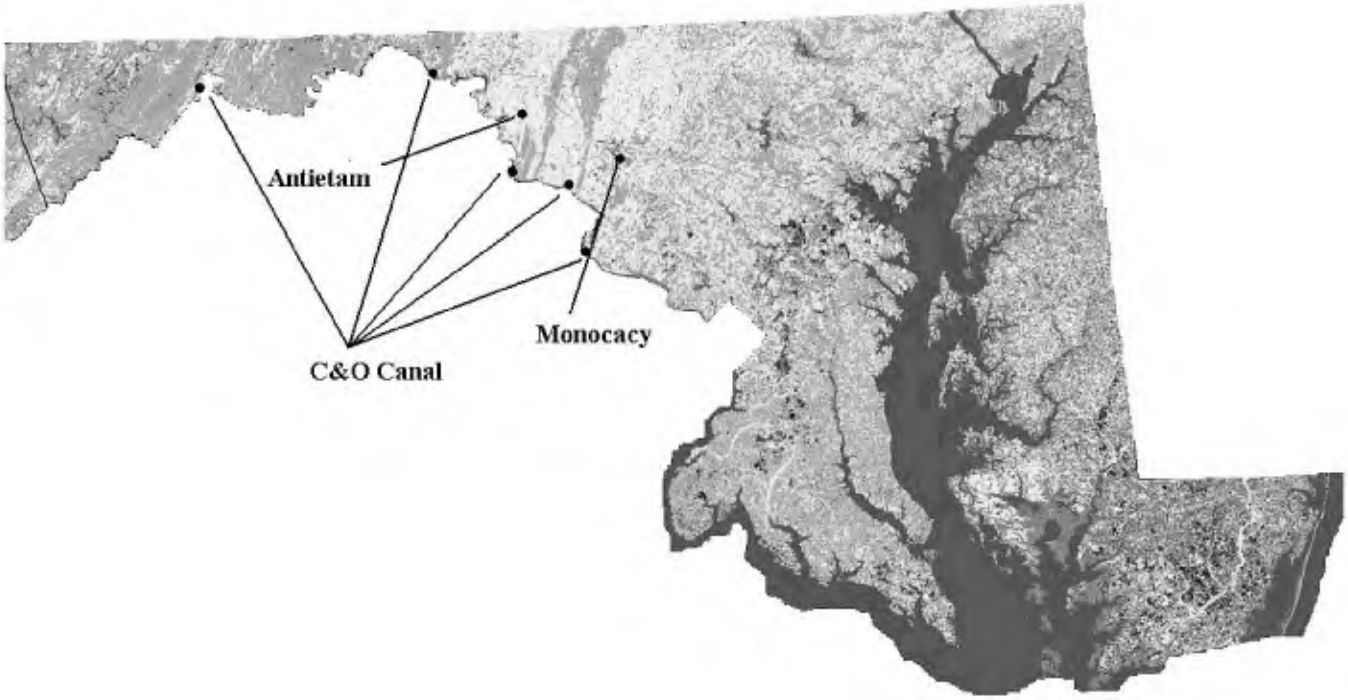

Figure 1. The study areas for deer herbivory within a landcover map of Maryland, USA (U.S. Geological Survey National Land Cover Data Set 1992; http://landcover.usgs.gov/nlcd). The C&O Canal had 5 individual fields distributed along the Potomac River, while Antietam and Monocacy National Battlefield each contained 3 study fields.

We also examined if field configuration and surrounding landscape could be used to predict corn damage by deer.

STUDY AREA

Our study sites were located in Antietam National Battlefield (ANTI) in Sharpsburg, Maryland (39°27′N, 77°45′W), Monocacy (MONO) National Battlefield in Frederick, Maryland (39°25′N, 77°25′W), and along the Chesapeake and Ohio Canal (CHOH). Both ANTI and MONO are small NHPs (1.5 km^2 and 0.75 km^2, respectively) and consist of largely agricultural landscapes, with small woodlots surrounded by large fields of corn. The CHOH is a continuous 478-km forest corridor that follows the length of the Potomac River along the Maryland border and traverses a diverse landscape. Corn fields are interspersed throughout the CHOH (Fig. 1).

Deer densities are estimated annually by NPS staff using standard distance-sampling techniques (Buckland et al. 2001) and during our study ranged from 45 deer per km^2 in ANTI to 54 deer per km^2 in MONO (S. Bates, NPS, unpublished report). The NPS could not obtain a park-wide deer density estimate for the CHOH because of the park configuration. However, 2 CHOH sections surveyed near our study sites showed densities at 36 and 42 deer per km^2 (S. Bates, NPS, unpublished report). We assume, with a few localized exceptions, that these numbers are typical throughout CHOH.

METHODS

We chose agricultural fields based on a farmer's willingness to plant corn for 2 years, the location of the field relative to other sites (i.e., we did not use adjacent fields), and the configuration of the field (i.e., we excluded fields <120 m wide). We selected 3 fields each from ANTI and MONO, and we studied the same fields in both 2003 and 2004. We selected 5 fields in CHOH, but 1 field was not planted in 2003 due to flooding and 1 field was not used in 2004 due to failure to apply herbicide (Fig. 1). The average field was 9.4 ha, with the largest field encompassing 17.1 ha. Within each field we established 12 5 × 5m plots. We stratified the locations of these plots into interior (i.e., >60 m from forest) and edge (i.e., <20 m from forest) and, for each pair of plots, we fenced one to exclude deer. The location of the plots within each field was not random, with the edge plots placed closest to the largest woodlot and the interior plots placed directly interior to these plots.

We erected the exclosure fences after seeding, but prior to emergence (between late Apr and early Jun each yr). Each corner post was a 10-cm × 10-cm × 3-m wooden post sunk 0.6 m into a polyvinylchloride (PVC) sleeve that made for easy removal. Fencing material consisted of 4-cm × 4-cm nylon mesh, cut vertically at the bottom to allow medium-sized mammals access to the fenced plots; fenced plots also were open on top to allow access by birds. We established control plots in the same corn rows as fenced plots, approximately 5 m apart. Prior to corn harvest in 2003, we removed the fences, and plugged each PVC sleeve. We reconstructed plots in the same locations in 2004.

We examined each plot twice during the growing season: approximately 1 week after plant emergence (average date = 10 Jun) and prior to harvest (average date = 29 Sep) to determine damage. During the first examination, we

Figure 2. Examples of 3 classifications of corn (from left to right): good (>95% of kernels developed and all of rows normal), fair (>70% of kernels developed and >70% of rows normal), and poor (<70% of kernels developed, and <70% of rows normal), which we used to determine the effects of deer herbivory at 3 National Parks in Maryland, USA 2003–2004.

counted the number of emergent stalks and recorded any evidence of herbivory on each emergent. In the second examination, we counted the number of stalks, identified their height class, noted the condition of the ears of corn (Fig. 2), and determined the total field weight from 15 randomly selected stalks. We placed ears of corn in 3 quality classes based on germination of kernels and appearance. Kernels on good ears were >95% developed and all rows uniform; kernels on fair ears were 70–95% developed and had >70% of rows uniform; and kernels on poor ears were <70% developed and had <70% of rows uniform. We estimated the crop yield for each field site based on a standard yield equation which uses the average weight of individual corn stalks, number of stalks per m, and row spacing to determine total crop weight per ha (Eriksen et al. 2002). We used this equation as a guide to compare silage losses between fenced and unfenced plots (i.e., loss of silage due to deer herbivory).

We compared plots using an Analysis of Variance (ANOVA; Systat 11, Systat Software, Inc., San Jose, CA) with 3 dependent variables: field weight of 15 stalks, percentage of stalks with poor-quality corn, and percentage of stalks with corn. We used 5 categorical variables: year (2003 and 2004), park (ANTI, CHOH, and MONO), field, plot location within field (edge and interior), and access by deer. Although plots were in the same location each year, we did not consider the experimental setup a repeated-measures analysis because each plot was plowed, seeded, and herbicide applied annually. Deer also were not confined to the fields and experienced typical reshuffling during winter grouping and harvest on adjacent properties.

To evaluate differences between fields, we calculated metrics for field configuration (i.e., perimeter, area, perimeter:area ratio) and amount of surrounding forest to use as covariates for mean loss in stalk weight for the interior and edge plots in each field (GLM; Systat 11). We estimated the percentages of surrounding forest cover by placing 500-m and 1-km buffers around each field and we derived them from the 1992 United States Geological Survey National Land Cover Dataset (http://landcover.usgs.gov/nlcd). The percentage forest cover within the 500 m and 1 km buffers correlated strongly (Pearson $r = 0.936$), and we used the 500-m buffer exclusively for the analysis.

RESULTS

We sampled 126 (63 fenced) and 108 (54 fenced) plots in 22003 and 2004, respectively (Table 1). In 2003 we eliminated 9 plots from our analysis because herbicides were not applied on the plot between census periods. In 2004, we excluded 18 plots from analysis; we excluded 14 because herbicides were not applied, 3 plots were harvested prior to sampling, and 1 fence was compromised. When we discarded a fenced plot from analysis we also discarded its paired plot.

Table 1. Annual crop loss landscape variables for the 11 study fields in 3 National Historical Parks in Maryland, USA, 2003–2004. Negative values indicate higher weights for unfenced plots.

Field	Mean proportion crop loss[a]				Proportion forest cover[b]	Perimeter (m)	Area (ha)	Perimeter/ area ratio
	2003	SE	2004	SE				
Monocacy 1	0.03	0.07	−0.06	0.07	0.13	1,923	17.1	112.5
Monocacy 2	0.33	0.11	0.08	0.03	0.40	2,905	9.3	312.4
Monocacy 3	0.09	0.09	−0.05	0.08	0.32	1,449	5.9	245.6
Antietam 1	0.10	0.07	0.01	0.10	0.07	1,526	9.0	169.6
Antietam 2	0.08	0.12	−0.02	0.10	0.01	1,201	8.7	138.0
Antietam 3	0.32	0.02	0.51	0.06	0.13	1,022	6.4	159.7
C & O 1	n/a[c]		0.15	0.07	0.62	2,450	13.5	181.5
C & O 2	0.12	0.09	0.06	0.12	0.52	927	4.0	231.8
C & O 3	0.79	0.10	0.33	0.08	0.58	1,216	8.6	141.4
C & O 4	0.56	0.08	n/a[d]		0.60	1,922	8.3	231.6
C & O 5	0.09	0.07	0.04	0.14	0.63	1,492	13.0	114.8

[a] Compared from the mean wt (kg) of 15 stalks randomly chosen from paired 5 × 5-m plots.
[b] Within a 500-m buffer.
[c] Field not planted due to flooding.
[d] Field omitted due to lack of herbicide application.

Table 2. Percent crop loss attributed to deer for paired plots within 3 National Historical Parks in Maryland, USA, in 2003 and 2004. Negative numbers indicate % gain.

			Mean % loss due to deer[a]											
			Wt of 15 stalks				Corn stalks with ears				Ears not considered poor quality			
Site	Yr	Sample size	Interior[b]	SE	Edge[c]	SE	Interior	SE	Edge	SE	Interior	SE	Edge	SE
Monocacy	2003	18	19.0	8.8	10.9	8.1	21.1	11.2	21.6	7.8	7.8	7.4	16.9	11.4
	2004	18	−3.3	5.8	1.7	4.5	1.8	1.8	3.4	2.0	2.1	1.0	2.0	2.1
Antietam	2003	17	15.7	7.1	18.4	7.9	13.9	3.8	21.4	7.7	15.9	5.8	24.1	6.7
	2004	13	−17.2	13.9	13.7	12.1	12.9	4.6	36.5	13.5	−7.7	3.5	25.0	19.1
C&O canal	2003	24	27.8	9.6	50.1	10.5	46.1	12.5	50.4	11.9	26.4	9.0	24.0	7.3
	2004	19	8.1	6.6	24.3	8.1	16.6	7.1	26.2	11.1	9.4	9.7	9.4	14.3
Total		109	10.8	3.9	21.5	4.2	20.8	4.2	27.6	4.4	10.7	3.2	16.3	4.3

[a] We measured crop loss 3 ways: mean wt of 15 stalks (kg), percentage of stalks in 1 row with ears of corn; and percentage of ears of corn in 1 row that are judged to be of poor quality.
[b] >60 m from woodlot.
[c] <20 m from woodlot.

A summary of the differences between fenced and unfenced plots found a significant crop loss due to deer (Table 2). Deer exclusion resulted in a higher crop yield, with fenced plots averaging 17.8% higher corn weights (ANOVA, partial $F_{1,219} = 21.08$, $P < 0.001$), 24% more stalks with corn (ANOVA, partial $F_{1,219} = 80.08$, $P < 0.001$), and 40% less poor-quality corn ears than unfenced plots (ANOVA, partial $F_{1,219} = 21.49$, $P < 0.001$; Table 2). The mean weight of corn stalks differed between parks (ANOVA, partial $F_{2,219} = 5.0$, $P < 0.01$) and fields (ANOVA, partial $F_{9,219} = 19.43$, $P < 0.001$). Both mean percentage of stalks with corn and mean percentage of ears with poor corn differed by year (ANOVA, partial $F_{1,219} =$ 4.97 and 4.23, respectively, $P < 0.05$) and field (ANOVA, partial $F_{9,219} = 9.70$ and 7.78, respectively, $P < 0.001$). Only the mean % of ears with poor corn was affected by location of the plot within the field ($F_{1,219} = 5.84$, $P < 0.05$). There were no significant interactions observed. Herbivory on early season emergent stalks correlated with eventual crop lost, as measured by mean stalk weight (GLM partial $F_{1,19} = 11.59$, $r^2 = 0.45$, $P = 0.003$).

Farmers deal with silage yield and not mean stalk weight, but loss in stalk weight should directly affect silage yield for each field. It is difficult to use standard silage estimates (i.e., Eriksen et al. 2002) to estimate deer damage because silage yield estimates are based on random samples in a field and the crop losses due to deer are generally nonrandom. Given this caveat, we estimated losses in silage at CHOH for 2003 (43.5% or 13,445 kg/ha) and 2004 (16.2% or 7,172 kg/ha) due to deer damage. The average loss in silage yields were less for ANTI (9.1% or 2,801 kg/ha) and MONO (7.4% or 2,252 kg/ha). For all parks the loss was greatest in the 2003 growing season.

Landscape composition around each field appeared to affect crop loss. The more forest coverage within a 500-m radius surrounding each field, the greater the loss in mean stalk weight (GLM, partial $F_{1,32} = 8.20$, $P = 0.007$). The CHOH, which experienced the most crop damage, averaged 59% forested habitat within a 500-m radius of the field, as opposed to 28% forest cover for MONO and 7% forest cover for ANTI. Field size and perimeter-to-area ratio were not a significant predictors of loss in mean stalk weight.

DISCUSSION

Within the NHP fields we examined, deer reduced crop yields, whether measured by mean stalk weight, number of stalks with ears of corn, quality of corn, or silage yield. One difficulty in assessing deer damage to corn is that the damage is not consistent, varying annually, between fields, and even across a single field. Crop loss was greater in 2003 then 2004; this difference was obvious at the beginning of the growth season when we measured early season herbivory on emergents. The only obvious difference between the years was that the 2003 crops were planted up to 1 month later in the growing season due to field flooding.

The differences in crop loss between fields may be partially due to landscape differences. Small agricultural fields surrounded by large tracts of forest experienced the most crop loss. Although crop loss along the edge of fields generally was higher than crop loss in the center of fields, the difference was not significant. This result agrees with a study in Ohio that found no differences within 200 m of woodlots (Vecellio et al. 1994), but contrasts 2 studies that found proximity to a woodlot as an important determinant of loss (Shope 1970, Wywialowski 1996). We did have several fields with high perimeter:area ratios (Table 1) and we feel these narrow-shaped fields reduced the importance of plot location in determining crop damage. Overall, fields located in forest-dominated landscapes, such as most fields in CHOH, experienced the highest overall damage, and this damage was consistent throughout the field.

Deer densities in predominately agricultural areas that provide refuge from hunting often exhibit enhanced carrying capacities (Hansen et al. 1997). These higher densities will almost certainly exceed cultural carrying capacity and cause increased tensions between agricultural lease cooperators and NPS personnel. West and Parkhurst (2002) found over half of farmers in Virginia with zero or low levels of corn damage believe that the state's deer population should be reduced. This number jumped to over 93% for farmers who classified themselves as having severe damage to their crops.

With corn fields providing abundant food resources, and limited hunting pressure within NPS boundaries, solutions to crop damage in NHPs are elusive. Nonlethal measures at reducing crop damage due to deer are limited. Deterrents such as propane exploders and electronic guards have been proven to have limited efficacy (Gilsdorf et al. 2004). Scent or taste repellents also have proven unsuccessful deterrents. Though repellents eliciting fear have been more successful than taste-aversion repellents (Wagner and Nolte 2001), these are only applicable in protecting smaller resources such as home gardens or landscaping (Seamans et al. 2002). It may be possible to avert damage to emergents through spraying repellents, but significant damage does occur at later stages (VerCauteren and Hygnstrom 1998). West (1998) found that grain producers rarely used preventative measures due to the relatively low value per unit area of crops and that preventative measures likely would not be cost-effective.

Localized lethal management has worked in some states (McNulty et al. 1997), though programs are difficult to implement on government properties due to issues of liability and public relations (DeNicola et al. 1997). Many park managers are reluctant to implement a deer management program for fear of a lawsuit, despite a recent court victory at Gettysburg National Military Park (Leong and Decker 2005). However, lethal deer management appears to be the only viable, cost-prohibitive option at reducing deer
?4 damage at this time.

MANAGEMENT IMPLICATIONS

Documenting the level of deer damage is the first step toward developing a management plan. There are few shortcuts to estimating deer damage; crop damage must be assessed on a field-by-field basis, with damage to emergent plants an early indicator of how severe damage will be for that growing year. Fields embedded within a forested landscape will experience more damage than those in an agricultural landscape, but annual variation in crop damage is significant. We recommend enlisting the aid of agricultural lease holders in approaching state and local officials and incorporating community stakeholders as early in the management process. In linear parks, deer management programs should involve multiple private landowners and public jurisdictions to be effective. With the need to incorporate adjoining private lands in an effective management plan, state wildlife agencies can better provide outreach and implement regional management goals to achieve desired deer densities within the park.

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LITERATURE CITED

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling. Oxford University Press, New York, New York, USA.

Conover, M. R. 1994. Perceptions of grass-roots leaders of the agricultural community about wildlife damage on their farms and ranches. The Wildlife Society Bulletin 22:94–100.

Conover, M. R., and D. J. Decker. 1991. Wildlife damage to crops: perceptions of agricultural and wildlife professionals in 1957 and 1987. Wildlife Society Bulletin 19:46–52.

DeNicola, A. J., S. J. Weber, C. A. Bridges, and J. L. Stokes. 1997. Nontraditional techniques for management of overabundant deer populations. The Wildlife Society Bulletin 25:496–499.

Dolbeer, R. A. 1980. Blackbirds and corn in Ohio. U.S. Department of Interior, Fish and Wildlife Service, Resources Publication 136:1–18.

Eriksen, L., P. Shipley, and P. Steinhilber. 2002. Estimating corn silage yield. Department of Natural Resource Sciences and Landscape Architecture, Maryland Cooperative Extension,University of Maryland, College Park, USA.

Gilsdorf, J. M., S. E. Hygnstrom, K. C. VerCauteren, E. E. Blankenship, and R. M. Engeman. 2004. Propane exploders and electronic guards were ineffective at reducing deer damage in cornfields. Wildlife Society Bulletin 32:524–531.

Hansen, L. P., C. M. Nixon, and J. Beringer. 1997. Role of refuges in the dynamics of outlying deer populations. Pages 327–345 *in* W. J. McShea, H. B. Underwood, and J. H. Rappole, editors. The science of overabundance: deer population ecology and management. Smithsonian Institution Press, Washington, D.C., USA.

Leong, K. M., and D. J. Decker. 2005. White-tailed deer issues in NPS units: insights from natural resource managers in the northeastern U.S. HDRU series number 05–5 Department of Natural Resources, Cornell University, Ithaca, New York, USA.

McNulty, S. A., W. F. Porter, N. E. Mathews, and J. A. Hill. 1997. Localized management for reducing white-tailed deer populations. Wildlife Society Bulletin 25:265–271.

National Park Service. 1992. General Management Plan: final environmental impact statement for Antietam National Battlefield, Washington County, Maryland. Branch of Publications and Graphic Design, Denver Service Center, Colorado, USA.

Putman, R. J., and N. P. Moore. 1998. Impact of deer in lowland Britain on agriculture, forestry and conservation habitats. Mammal Review 28:141–164.

Seamans, T. W., B. F. Blackwell, and J. D. Cepek. 2002. Coyote hair as an area repellent for white-tailed deer. International Journal of Pest Management 48:301–306.

Shapiro, C. A., T. A. Peterson, and A. D. Flowerday. 1986. Yield loss due to simulated hail damage on corn: a comparison of actual and predicted values. Agronomy Journal 78:585–589.

Shope, W. K. 1970. Behavioral characteristics of the white-tailed deer (*Odocoileus virginianus*) in relation to crop damage in Centre County, Pennsylvania. Thesis, The Pennsylvania State University, University Park, USA.

Tzilkowski, W. M., M. C. Brittingham, and M. J. Lovallo. 2002. Wildlife damage to corn in Pennsylvania: farmer and on-the-ground estimates. Wildlife Society Bulletin 66:678–682.

Vecellio, G. M., R. H. Yahner, and G. L. Storm. 1994. Crop damage by deer at Gettysburg Park. The Wildlife Society Bulletin, 22:89–93.

Virginia Agricultural Statistics Service. 1986–1989. Virginia crops and livestock. Volumes 58–61. Virginia Agricultural Statistics Service, Virginia, USA.

Virginia Crop Reporting Service. 1985. Virginia Agricultural Service Bulletin 54:117.

VerCauteren, K. C., and S. E. Hygnstrom. 1998. Effects of agricultural

activities and hunting on home ranges of female white-tailed deer. Journal of Wildlife Management 62:280–285.
Vorst, J. J. 1986. Assessing hail damage to corn. University of Nebraska NebGuide 803. Institute of Agriculture and Natural Resources, Cooperative Extension Service,University of Nebraska, Lincoln, USA.
Wagner, K. K., and D. L. Nolte. 2001. Comparison of active ingredients and delivery systems in deer repellents. Wildlife Society Bulletin 29:322–330.
West, B. C. 1998. Deer damage in Virginia: implications for management. Thesis, Virginia Polytechnic Institute and State University, Blacksburg, USA
West, B. C., and J. A. Parkhurst. 2002. Interactions between deer damage, deer density, and stakeholder attitudes in Virginia. Wildlife Society Bulletin 30:139–147.
Wywialowski, A.P. 1996. Wildlife damage to field corn in 1993. Wildlife Society Bulletin 24:264–271.

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