Spent-shot availability and ingestion on areas managed for mourning doves

John H. Schulz, Joshua J. Millspaugh, Brian E. Washburn, Gary R. Wester, James T. Lanigan III, and J. Christian Franson

Abstract Mourning dove (*Zenaida macroura*) hunting is becoming increasingly popular, especially in managed shooting fields. Given the possible increase in the availability of lead (Pb) shot on these areas, our objective was to estimate availability and ingestion of spent shot at the Eagle Bluffs Conservation Area (EBCA, hunted with nontoxic shot) and the James A. Reed Memorial Wildlife Area (JARWA, hunted with Pb shot) in Missouri. During 1998, we collected soil samples one or 2 weeks prior to the hunting season (prehunt) and after 4 days of dove hunting (posthunt). We also collected information on number of doves harvested, number of shots fired, shotgun gauge, and shotshell size used. Dove carcasses were collected on both areas during 1998–99. At EBCA, 60 hunters deposited an estimated 64,775 pellets/ha of nontoxic shot on or around the managed field. At JARWA, approximately 1,086,275 pellets/ha of Pb shot were deposited by 728 hunters. Our posthunt estimates of spent-shot availability from soil sampling were 0 pellets/ha for EBCA and 6,342 pellets/ha for JARWA. Our findings suggest that existing soil sampling protocols may not provide accurate estimates of spent-shot availability in managed dove shooting fields. During 1998–99, 15 of 310 (4.8%) mourning doves collected from EBCA had ingested nontoxic shot. Of those doves, 6 (40.0%) contained ≥7 shot pellets. In comparison, only 2 of 574 (0.3%) doves collected from JARWA had ingested Pb shot. Because a greater proportion of doves ingested multiple steel pellets compared to Pb pellets, we suggest that doves feeding in fields hunted with Pb shot may succumb to acute Pb toxicosis and thus become unavailable to harvest, resulting in an underestimate of ingestion rates. Although further research is needed to test this hypothesis, our findings may partially explain why previous studies have shown few doves with ingested Pb shot despite their feeding on areas with high Pb shot availability.

Key words lead, nontoxic shot, Missouri, mourning doves, Pb, spent shot, *Zenaida macroura*

Although lead (Pb) is a ubiquitous and versatile metal, it is very toxic and acts as a nonspecific poison affecting all vertebrates (Mielke 1999). Since the phased-in use of nontoxic shot for waterfowl hunting during 1987-92 (United States Fish and Wildlife Service [USFWS] 1986, 1988), there has been a growing concern about exposure of nonwaterfowl species to Pb resulting from recreational hunting (Kendall et al. 1996). Although Pb poisoning has been reported in ≥30 nonwaterfowl species, the true number of affected species may be higher (Franson 1996). The most common means of exposure is direct ingestion of spent Pb shot (Kendall et al. 1996).

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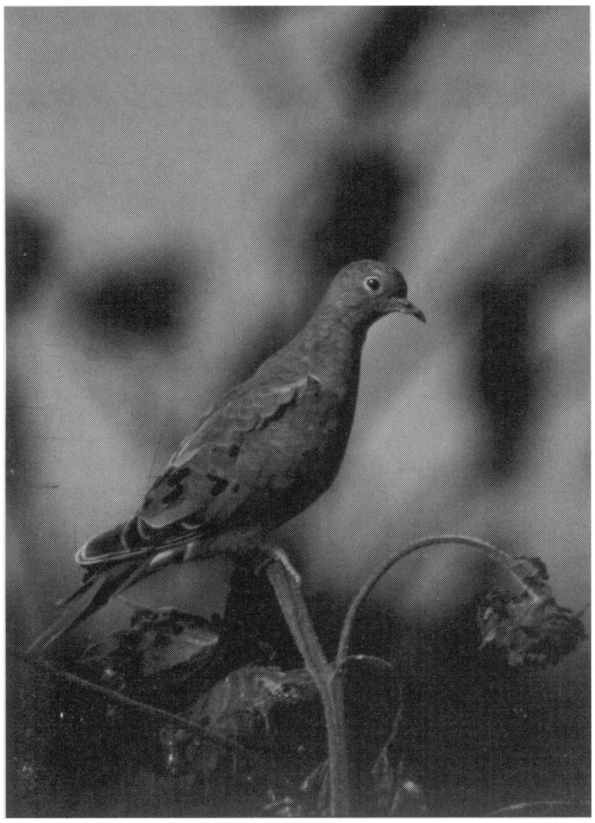

Mourning dove makes use of sunflowers in a managed shooting field on a Missouri Department of Conservation public hunting area during the hunting season. Photo by Jim Rathert.

Ingestion of Pb pellets has been reported for numerous upland gamebirds, including northern bobwhite (*Colinus virginianus*; Westemeier 1966, Best et al. 1992*a*), scaled quail (*Callipepla squamata*; Campbell 1950, Best et al. 1992*a*), ring-necked pheasants (*Phasianus colchicus*; Hunter and Rosen 1965), ruffed grouse (*Bonasa umbellus*; Kendall et al. 1984), and mourning doves (*Zenaida macroura*; Lewis and Legler 1968, Best et al. 1992*b*, Kendall et al. 1996). Lead poisoning also may have secondary impacts on avian predators and scavengers that consume moribund or dead upland gamebirds containing ingested or embedded Pb shot (USFWS 1986, Franson 1996, Kendall et al. 1996).

Given the relatively long-term trend decline in many upland gamebird populations (Church et al. 1993, Riley and Riley 1999) and the resulting decline in upland gamebird hunters (Burger et al. 1999), many wildlife managers have focused on increasing mourning dove hunting opportunities to ameliorate these hunter declines. Managers commonly provide feeding fields near urban population centers to increase dove shooting opportunities close to where dove hunters live (Missouri Department of Conservation, unpublished data).

Mourning doves are primarily granivorous ground feeders (Lewis 1993), their diet containing more than 90% grain crop seeds (Korschgen 1958). Mourning doves have delicate feet and do not locate food by scratching in the ground litter or probing the ground with their bill; most feeding activity occurs by pecking at seeds located on bare ground (Lewis 1993). Thus, feeding fields preferred by mourning doves are characterized by an abundance of grain seeds scattered on relatively bare ground with little vegetative cover; common crop seeds include sunflowers (*Helianthus* spp.), wheat (*Triticum* spp.), millets (*Setaria* spp.), and grain sorghum (*Sorghum* spp.; Baskett 1993). Given the combination of bare ground scattered with crop seeds, relatively high hunter densities (3.0–5.0 hunters/ha), and long traditions of hunting the same managed crop fields annually, deposition of spent Pb shot may pose toxicological problems for mourning doves and other granivorous birds feeding in those managed fields.

Several studies have investigated availability of spent Pb shot and its impact on mourning doves. Posthunt soil samples collected from a managed dove field in Tennessee indicated 107,637 shot/ha, with 1.0% of the 1,949 hunter-killed doves containing ingested shot (Lewis and Legler 1968). A traditional mourning dove hunting area in New Mexico showed posthunt estimates of 860,185 shot/ha, with 0.2% of the 420 hunter-killed doves containing ingested Pb shot (Best et al. 1992*b*). Gizzard and crop examination of 412 birds collected from 6 game management areas in Maryland, Virginia, North Carolina, and South Carolina indicated 2.4% of the individuals contained ingested Pb shot (Kendall and Scanlon 1979). A sample of 62 hunter-killed mourning doves in Maryland revealed that 6.5% had ingested Pb shot (Locke and Bagley 1967). In Indiana, posthunt shot densities in 13 fields increased 645% to 24,665 shot/ha, with shot densities varying among fields due to differences in hunter density (Castrale 1989).

The paradox from previous studies is the low incidence of hunter-killed doves with ingested shot, given the high shot availability on managed fields. It is possible that as mourning doves ingest $\geq$2 Pb pellets, they quickly succumb to acute Pb toxicosis and become increasingly less available to hunter harvest (Kendall et al. 1996), resulting in an

underestimation of pellet ingestion rates. The acute toxicosis hypothesis differs vastly from the chronic Pb poisoning model widely accepted for waterfowl Pb exposure (Sanderson and Bellrose 1986). Individuals with chronic Pb toxicosis usually ingest a small number of pellets and, over a period of several weeks, lose 30-50% of their body mass and exhibit characteristic diagnostic behaviors. In comparison, acute Pb toxicosis occurs where relatively large numbers of pellets are ingested, and birds succumb to damage of the central nervous system and disruption of hemoglobin function and synthesis (Eisler 1988). In addition, the relatively small body size of mourning doves makes it difficult to encounter Pb-poisoned individuals because such birds may be quickly depredated or scavenged. Because carcasses are often difficult to locate and field biologists are usually uncertain about protocols for individual unknown wildlife deaths, postmortem examinations of wild birds are sporadic and involve small sample sizes. Documentation of Pb poisoning is at best a chance event (Locke and Friend 1992), leading biologists to assume incorrectly that Pb poisoning in upland settings is relatively unimportant or insignificant. Our objectives, therefore, were to determine spent-shot availability on managed mourning dove hunting fields and determine spent-shot ingestion by hunter-killed doves on one area hunted with Pb shot and another area hunted with nontoxic shot.

Study areas and methods

Study areas

This study was conducted at 2 conservation areas managed by the Missouri Department of Conservation: Eagle Bluffs Conservation Area (EBCA) and James A. Reed Memorial Wildlife Area (JARWA). During 1998-99, managed sunflower and wheat fields were available for dove hunting on each area, and different-sized fields were scattered throughout the areas. EBCA encompassed 1,439 ha and was located 16 km southwest of Columbia, Missouri. Wetlands and grasslands comprised most habitats there. Managed dove hunting had occurred on the EBCA study area since 1995. The hunting field we examined for spent pellets at EBCA was 8.9 ha and comprised of Onawa silty clay loam and Sapry very fine sandy loam soils (Krusekopf and Scrivner 1962).

JARWA, about 967 ha, was located 22 km southeast of Kansas City, Missouri, and was comprised primarily of grassland and forested habitats. Managed dove hunting on JARWA had occurred since the early 1960s. The field we examined there was 5.1 ha and comprised of Macksburg silt loam soils (Preston 1984).

Dove hunting activities

On 1, 3, 5, and 7 September of 1998, mourning dove hunting occurred at the EBCA field; shooting hours were 1300 to 1700 hours Central Standard Time. On alternate days (2, 4, and 6 September), this field was refuged (no hunting allowed). Dove hunters at EBCA were required to use only nontoxic shot because of Pb shot restrictions for waterfowl hunting on the area. The field at JARWA was hunted each day from 1-4 September 1998; shooting hours were 1200 to sunset Central Standard Time. Hunters at JARWA were allowed to use Pb shot. At both areas, all hunters were required to check in and out, allowing us to collect data on number of doves killed, number of shots fired, shotgun gauge, and shotshell size.

Dove hunting regimes differed between our study areas. At EBCA, hunters were assigned to one of 25 available stations spaced 37 m apart, with no more than 2 hunters/station. Number of hunters that could be accommodated was $\leq$50 daily. Shooting stations were arranged linearly along the east edge of the mowed section of the sunflower field (Figure 1*a*). At JARWA, all hunters were assigned to a specific field and allowed to hunt only along its perimeter. Hunter density was 1.2/ha; $\leq$500 hunters could be accommodated daily throughout the area.

Spent-shot availability

Conceptually, our evaluation of spent-shot availability was an impact assessment design as described by Skalski and Robson (1992) and Morrison et al. (2001) (i.e., treatments were not randomized and replication was not possible because there were only 2 study sites). We used the soil sampling protocol described by Lewis and Legler (1968), Castrale (1989), and Best et al. (1992*b*) to determine availability of spent shot prior to (prehunt) and following 4 days of dove shooting activities (posthunt) on fields specifically managed to attract mourning doves. At each soil sampling location, we placed a steel plate measuring 30.5 × 30.5 cm and 1.0 cm thick on the soil surface (Lewis and Legler 1968, Castrale 1989, Best et al. 1992*b*). Next, we dug a 5-cm-deep trench around the soil sample

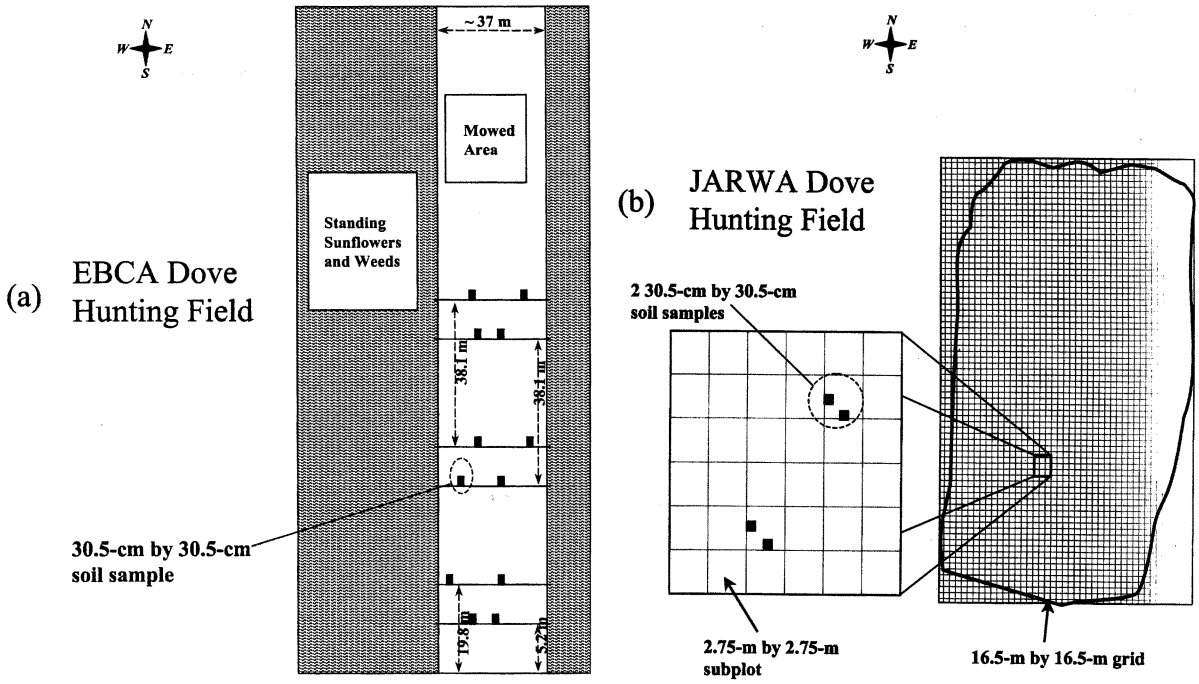

Figure 1. Schematic diagram of the systematic random sampling systems used to estimate spent-shot availability at one shooting field at the Eagle Bluffs Conservation Area (*a*) and one shooting field at the James A. Reed Memorial Wildlife Area (*b*) during 1998.

plot, using the edges of the soil sampling plate as a guide. We lifted the steel plate and removed all vegetation and litter from the 30.5 × 30.5-cm area, being careful to remove soil from the roots and replacing it where the plant was removed. Using a small shovel, we removed the top 1-cm-thick layer of soil and placed it in a labeled plastic bag.

Prehunt soil sampling for spent-shot availability occurred on 27 August 1998 at EBCA and on 22–23 August and 29–30 August 1998 at JARWA. We collected posthunt soil samples on 8 September 1998 at EBCA and 5–6 September 1998 at JARWA. Although the soil samples at EBCA and JARWA were collected by different individuals, the same 2 people collected the prehunt and posthunt samples from each area. Soil sampling schemes differed between the 2 areas due to differences in the hunting regimes on the areas, as discussed previously.

EBCA. We used systematic random sampling to identify soil sample plot locations for assessing spent-shot availability (S. L. Sheriff and Z. He, Missouri Department of Conservation, personal communication). Specifically, we randomly established the first pair of transects at 5.2 m and 19.8 m from the southern edge of the mowed area (Figure 1*a*). From there on, we established a series of parallel transects at 38.1-m intervals north of the initial 2 transects. We placed wooden stakes at 2 randomly determined soil sampling locations along each transect. We collected the prehunt soil samples at the southwest corner of the wooden stakes, and collected posthunt samples 0.6 m from the opposite side of the wooden stake.

We acknowledge that because of the location of the shooting stations, an unknown proportion of spent shot at EBCA would not fall into the mowed area where we collected our soil samples, and that the trajectory of some shots fired by dove hunters would carry the spent pellets beyond our zone of sampling (i.e., the estimated maximum trajectory of No. 8 or No. 6 shot is approximately 200 meters [National Rifle Association 1991]). However, we assumed that dove feeding activities occurred on the mowed section of the field because doves tend to feed on areas of bare ground covered with seed. We also assumed that the shot which did not fall in the mowed area was unavailable to feeding doves due to the density of the vegetation on the surrounding locations. Thus, our assessment of shot availability considered only shot available to feeding doves.

JARWA. We identified soil sample plot locations at JARWA using a different systematic random sampling system because of differences mentioned

previously in hunter distribution between the areas. Specifically, we divided one field into 271-m^2 plots, using the southwestern corner of the field as a starting reference point (Figure 1*b*). We then divided each 271-m^2 plot into 36 2.75 × 2.75-m subplots. Next, we randomly selected 2 of the 36 subplots in each plot for soil sampling to estimate spent-shot availability. From the southwest corner of each selected subplot, we located and marked a point 0.6 m due north with a wooden stake. We collected the prehunt soil sample using the steel plate procedure as described above, and collected the posthunt sample at a point 0.6 m due east of the southwest corner of each selected subplot using the same procedure.

Soil sample processing. We labeled all soil samples individually and took them to the laboratory for processing and analysis for spent shot (Lewis and Legler 1968, Castrale 1989, Best et al. 1992*b*). We determined the weight of each sample (to the nearest 0.25 kg) using a temperature-compensated spring dial scale (Homs Corporation, Belmont, Calif., USA); we determined the volume (to the nearest 100 mL) using a 2,000-mL graduated beaker (Nalgene Labware, Rochester, N.Y., USA). We poured each soil sample into a series of different-sized mesh screens, starting with the largest mesh (4.0 mm, Fisher Scientific Co. Standard Testing Sieve #5), next using a smaller mesh (1.0 mm, Fisher Scientific Co. Standard Testing Sieve #18), and finally the smallest size mesh (0.0197 mm, Fisher Scientific Co. Standard Testing Sieve #35). We flushed soil samples with a steady stream of water to facilitate removal of fine soil particles. We poured the contents remaining in the #18 and #35 screen sieves into a white 5 × 23 × 33-cm tray, permitting the removal of any shot present. We identified collected shot by size and type (nontoxic or Pb).

Ingested shot

We determined incidence of ingested shot for hunter-killed doves at EBCA and JARWA during 1998–99. Due to the low number of carcasses collected in 1998, we collected carcasses again in 1999, obtaining them from hunters, and removed the breast meat. We placed the remainder of the birds in a plastic bag, froze it, and shipped samples to the National Wildlife Health Center (NWHC; 6006 Schroeder Road, Madison, Wis., USA). At NWHC, gizzards were removed and radiographed. We visually examined gizzards with radiographic evidence of shot. We classified pellets that were shot-in or ingested according to presence or absence of entry wounds in the gizzards, along with the physical characteristics of shot (e.g., presence of deformed Pb shot).

Statistical analyses

We compared abundance of spent shot in prehunt and posthunt soil samples from EBCA and JARWA using a Mann-Whitney U test (Devore and Peck 1986). Data on abundance of spent shot were not distributed normally (Poisson distribution) and thus warranted use of a nonparametric test. We used 2-way analysis of variance (ANOVA) to compare the weight and volume of prehunt and posthunt soil samples collected at EBCA and JARWA (Neter et al. 1990). We considered differences significant at $\alpha = 0.05$. We compared means using Fisher's protected LSD test (Neter et al. 1990). Soil sample weight and volume data were distributed normally and exhibited constant variance across treatments.

Results

At EBCA, 60 hunters harvested 275 mourning doves and reported firing an average of 6.6 shots/harvested dove (SE=0.09) during the 4 days of hunting during 1998. During these 4 days, 1,527 shotshells were fired at doves, depositing 41 kg of nontoxic shot or approximately 576,500 pellets on or around the 8.9-ha hunted dove field (64,775 pellets/ha). At JARWA, 728 hunters harvested 2,403 mourning doves and reported firing an average of 6.3 shots/harvested dove (SE=0.01) during the 4 days of hunting during 1998. During these 4 days at JARWA, 14,087 shotshells were fired, depositing 430 kg of Pb shot or approximately 5,540,000 pellets on or around the 36 ha of managed dove fields (1,086,275 pellets/ha).

Spent-shot availability

No shot pellets were found in the 206 soil samples (prehunt and posthunt combined) collected from EBCA (Table 1). At JARWA, 0.3% ($n=1$) of the prehunt soil samples contained shot pellets, whereas 4.1% ($n=13$) of the posthunt soil samples contained 1 or 2 shot pellets (Table 1). As expected, amount of posthunt spent shot was greater ($U=10.53, P=0.001$) than prehunt spent shot levels at JARWA (Table 1).

Weight and volume differed for soil samples collected from EBCA and JARWA (Table 2). Weight of soil samples to estimate spent shot varied between

Table 1. Abundance of spent shot in soil samples collected prior to (prehunt) and following 4 days of hunting (posthunt) at 2 shooting fields, one at the Eagle Bluffs Conservation Area (EBCA, nontoxic shot) and one at the James A. Reed Memorial Wildlife Area (JARWA, Pb shot), in Missouri during August–September 1998.

Area	No. of samples	Total No. of pellets found	No. of samples with pellets	Estimated number of pellets per hectare
EBCA (nontoxic shot)				
Prehunt	102	0	0	0
Posthunt	104	0	0	0
JARWA (Pb shot)				
Prehunt	314	1	1	353
Posthunt	314	18	13	6,342

Table 2. Characteristics of soil samples collected to determine Pb shot abundance prior to (prehunt) and following 4 days of hunting (posthunt) at 2 shooting fields, one at the Eagle Bluffs Conservation Area (EBCA) and one at the James A. Reed Memorial Wildlife Area (JARWA), in Missouri, during August–September 1998.

	Soil sample characteristics					
	Weight (kg)			Volume (mL)		
Area	n	$\bar{x}$	SE	n	$\bar{x}$	SE
EBCA						
Prehunt	102	1.7 *a*[a]	0.04	51	1580 *a*	50.2
Posthunt	104	1.7 *a*	0.04	92	1640 *a*	41.3
JARWA						
Prehunt	314	1.1 *b*	0.02	314	950 *b*	20.3
Posthunt	314	1.0 *c*	0.02	314	930 *b*	17.9

[a] Means within the same column with the same letter do not differ ($P > 0.05$) according to a Fisher's protected LSD test.

the 2 areas ($F_{1,833}=581.12$, $P\leq0.001$). There was an area × date interaction ($F_{1,833}=5.63$, $P=0.02$). Although weight of soil samples collected prehunt and posthunt at EBCA did not differ ($F_{1,205}=1.43$, $P=0.23$), prehunt soil samples were heavier ($F_{1,627}=6.07$, $P=0.01$) than posthunt soil samples at JARWA (Table 2). The volume of soil samples collected to estimate spent shot also varied between the 2 areas ($F_{1,770}=446.15$, $P\leq0.001$), but was similar for prehunt and posthunt periods for each area ($F_{1,770}=0.03$, $P=0.87$; Table 2).

Ingested shot

None of the 46 mourning doves sampled from the JARWA in 1998 had ingested spent shot. In 1999, 2 of the 528 (0.4%) mourning doves examined from the JARWA had ingested spent shot—1 Pb pellet in each case. At EBCA, 4 of 94 (4.3%) doves examined contained ingested shot during 1998 and 11 of 216 (5.1%) collected in 1999 had ingested spent shot. Of the 15 doves collected on EBCA with ingested shot, 14 contained steel shot exclusively and one contained both steel and Pb pellets. Notably, 6 of 15 (40.0%) of the doves with ingested shot contained ≥7 pellets/dove (7, 7, 8, 17, 21, 23 steel pellets/dove respectively).

Discussion

As expected, the posthunt estimates of shot availability at JARWA suggest that more shot was available following hunting; however, our soil sampling data suggest that only 0.6% of the pellets fired during hunting activities may be available to doves. Furthermore, our posthunt estimates from soil sampling suggest that no nontoxic shot pellets fired during hunting at EBCA were available to feeding mourning doves. Without corresponding data on ingestion of Pb and nontoxic shot, these findings indicate superficially that even though a large number of shot is deposited on the 2 areas, only a very small proportion may be actually available to feeding mourning doves.

Our prehunt and posthunt estimates of available spent shot are considerably lower than levels reported in other studies. Lewis and Legler (1968) reported prehunt levels of 27,225 lead shot pellets/ha and posthunt levels of 108,900 pellets/ha in a managed dove field in Tennessee. Best et al. (1992*b*) found that prehunt amounts of lead shot were 167,593 pellets/ha and posthunt estimates were 231,731 to 860,185 pellets/ha in New Mexico.

These combined results indicate that protocols for measuring spent-shot availability in upland settings (Lewis and Legler 1968, Castrale 1989, Best et al. 1992*b*) may provide inaccurate estimates of actual shot availability. We believe that differences in weight and volume of soil samples between our 2 areas (Table 2) were due to one or more important factors. An observer bias was likely associated with differences in the depth of soil samples collected. In addition, the physical characteristics (e.g., texture) of soils varied considerably between the 2 areas and resulted in further variation in the weight and volume of samples. Soil moisture conditions during sampling activities also may have influenced sample characteristics. This variability may be especially critical on dove shooting areas

Area manager Matt Fenoff of the J. A. Reed Memorial Wildlife Area demonstrates sunflower field conditions during the growing season; later, in August, most of the field will be mowed, making the sunflower seeds and spent shot available to mourning doves and other surface-feeding songbirds. Photo by John H. Schulz.

that have a long tradition of hunting and where spent shot can accumulate in the upper soil strata. Correspondingly, differences in soil types and characteristics also could impact amount of time shot is available to feeding birds before it travels through the soil profile and becomes unavailable in its elemental form (Jorgensen and Willems 1987). Given the crude techniques used in the existing soil sampling procedure (Lewis and Legler 1968, Castrale 1989, Best et al. 1992*b*), minor differences in depth of the soil sample collected can have a profound impact on estimates of available shot.

Differing amounts of vegetative material on the soil surface also may affect accuracy of the soil sampling technique and may underestimate shot availability. For example, on a burned wheat field, amount of vegetative material would be minimal and would therefore have little impact on soil sampling. In contrast, on a managed sunflower field with a ragweed (*Ambrosia* spp.) component, the vegetative material may contain some spent shot (e.g., shot pellets embedded in the sunflower or ragweed stalks). Shot-availability estimates become biased when the vegetative material is removed prior to soil sampling or when plots with standing vegetation are sampled.

Our shot-ingestion data obtained from birds collected at Pb and nontoxic shot fields may provide support for the assumption that mourning doves that ingest ≥2 Pb pellets may quickly become debilitated and therefore are increasingly less available to hunter harvest (Kendall et al. 1996). This also may help explain why previous studies have shown relatively high Pb shot availability and seemingly low Pb pellet ingestion rates of 1.0–6.5%, and correspondingly low numbers of pellets per dove (Locke and Bagley 1967, Lewis and Legler 1968, Best et al. 1992*b*). The proportion of doves in our study with ingested steel shot was within the range of these published estimates (4.3% in 1998, 5.1% in 1999). However, number of birds with ≥7 steel shot pellets shows that doves often acquire multiple pellets. In addition, the actual proportion of doves with ingested steel shot could have been much higher on the lightly hunted EBCA if hunter density and corresponding shot availability were similar to the more intensively hunted JARWA (60 hunters at EBCA vs. 728 hunters at JARWA; 1,527 shots fired at EBCA vs. 14,087 shots fired at JARWA). We acknowledge the feasibility of an alternative hypothesis proposing that doves ingesting multiple steel pellets may have greater opportunity to ingest more pellets due to decreased hunter disturbance (i.e., hunting on alternate days and lower hunter density).

Further laboratory research is needed to investigate potential differences in ingestion of Pb and various nontoxic shot pellets and potential differences in shot-ingestion rates due to shot size and type. Previous laboratory experiments have focused on determination of Pb toxicosis and effects on reproduction based on gavage dosages of Pb shot with relatively low dosages of Pb shot (McConnell 1967, Buerger et al. 1986). Our data (i.e., birds with ≥7 shot pellets) suggest the possibility that mourning doves may actively search for spent pellets, and thus further research is needed to address this hypothesis of acute Pb toxicosis.

Surface soil samples were collected with a steel plate measuring 30.5 × 30.5 cm and 1.0 cm thick. Using the edges of the soil sampling plate as a guide, we dug a 5-cm-deep trench around the plot, and removed the top 1-cm-thick layer of soil and placed it in a labeled plastic bag. Photo by Gary R. Wester.

Wooden stakes were used to lay out 2 different soil sampling schemes on the J. A. Reed Memorial Wildlife Area and Eagle Bluffs Conservation Area. Prehunt soil sampling occurred 27 August 1998 at EBCA and on 22–23 August and 29–30 August 1998 at JARWA; posthunt soil sampling occurred on 8 September 1998 at EBCA and 5–6 September 1998 at JARWA. Photo by Gary R. Wester.

Biologists have previously assumed that Pb toxicosis in upland gamebirds, if it existed at all, was a minor issue due to the low density of shot pellets and the minimal impacts of chronic poisoning in a few individuals. We believe that Pb toxicosis due to recreational hunting activities may be more critical than previously thought and suggest that further research is needed to address the questions concerning shot ingestion in upland settings and evaluate impacts to other wildlife that may use managed dove fields. Regardless of the information generated from research, value judgments must ultimately be made concerning level of appropriate and acceptable risk of Pb exposure from the deposition of spent shot resulting from recreational hunting activities.

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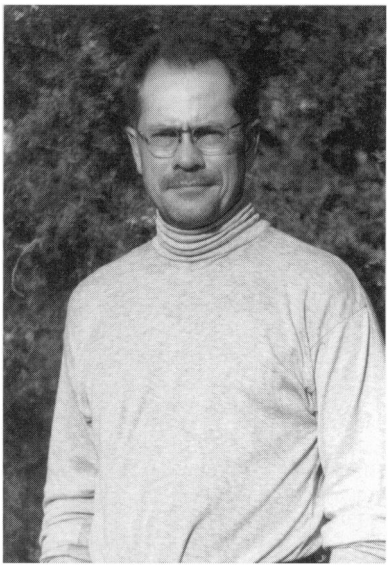

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