A. Title Page

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Effect of Soil Disturbance on Lead Shot Available to Waterfowl

by

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B. Restatement of problem researched or creativity

The overall objective of this study was to evaluate changes in lead shot distribution and availability to wintering waterfowl at Halowell Reservoir. Lead poisoning has been recognized as an important mortality factor in waterfowl since the late 1800s. Bellrose (1959) estimated that 2% to 3% of the fall flight of ducks were killed by lead poisoning each year and mortality is more frequent in the Mississippi Flyway than any other flyway. Nationwide conversion to non-toxic shot was expected to quickly reduce waterfowl mortality from lead poisoning because most lead pellets deposited during each season gravitate to deeper soil strata and become less available to waterfowl within a year of deposition, at least in light soils (Bellrose 1959). However, heavier soils can impede pellet movement, result in accumulation of shot pellets (Bellrose 1959, White and Stendell 1977), and prolong the threat to waterfowl. Accumulation and prevalence of pellets has been documented in several habitats including fields, emergent wetlands, and tidal marshes but little evaluation has been done in forested wetlands, a habitat used heavily by waterfowl and hunters in the Mississippi Alluvial Valley of the Mississippi Flyway.

Lead poisoning of waterfowl occurs when birds consume spent lead pellets while searching for food and grit in soils. Once ingested, pellets are eroded in the gizzard and lead salts are released; salts can adversely impact avian digestive, circulatory, nervous, and immune systems. Just one pellet can be lethal to birds but many factors such as species, sex, age, diet, grit availability, and physiologic state can influence mortality of birds (Sanderson and Bellrose 1986). Pellets from 2-6 inches deep in soils are considered available to waterfowl (Bellrose 1959, Moser 1992). Concentrations greater than 20,000 pellets/acre are considered to be dangerous levels to waterfowl (Anderson and Havera 1989). Concentrations of 8,712 pellets/acre are considered available in quantity to waterfowl (Jessen and Lound 1959).

Bellrose (1959) stated that availability of lead shot is determined by several factors: 1) shooting intensity or amount of shot on the bottom of substrates, 2) firmness of soils, 3) size of pellets, 4) water depth, and 5) ice cover. Spent shot apparently concentrates near the soil surface and may be easily consumed by waterfowl (Mudge 1984, Flint 1998, Schranck and Dollahon 1975, White and Stendell 1977, Wycoff et al 1972). Hohman et al. (1995) stated that managers should prioritize reducing lead shot availability in important waterfowl concentration areas that are known to contain lead shot. The authors further argue that managers should work to eliminate lead from sediments containing waterfowl foods by evaluating methods such as disking and plowing.

Studies have shown that tillage can reduce lead shot concentrations near the surface of the soil. Fredrickson et al. (1977) found that tillage reduced the availability of lead shot by distributing it deeper into the soil. Tillage also provides beneficial soil disturbance (Fredrickson et al 1977, Fredrickson and Taylor 1982, Fredrickson 1991). Wooley (1979) found that 50% of lead pellets existed 3-5 inches below the soil surface, suggesting that tillage or a hardpan may allow shot to accumulate at these depths. Esslinger and Klimstra (1983) found that tillage from a moldboard plow and disk reduced lead shot by 86% in the top inch of soil. Research has demonstrated that varying degrees of tillage will redistribute pellets deeper into the soil profile making them unavailable to foraging waterfowl. However, it is unclear if repeated disking over time will redistribute lead pellets closer to the soil surface.

C. Brief Review of the Research Procedures

We established 4 parallel and evenly spaced half-mile transects in each of 4 quadrants of the reservoir. We collected 8 soil core samples (9.53 cm in diameter, 3.75 inches) to a depth of

20.3 cm (8 inches) at randomly selected sites along each transect corridor (32 samples per quadrat and 128 total samples). All areas within the exterior levee were potentially sampled. Soil samples were placed in custom-fit boxes to maintain spatial integrity of the soil column. Boxed soil samples were exposed to X-rays at 110 Kvz and 100 milliamps for 1/30th of a second on a 300ma, 125 Kvp X-ray machine after testing indicated good detection of lead and steel pellets with this exposure. We measured the location of indicated pellet images on radiograph films to estimate shot depth in the soil column.

We manually searched all samples associated with indicated or possible pellet radiograph images. Each soil sample was separated into surface (top 5.1 cm) or subsurface subsamples (bottom 15.2 cm) and washed through 2.0mm and 1.5mm sieves to recover shot pellets. Recovered pellets will be tested for magnetism and hardness to determine lead or steel composition. We estimated shot densities in surface and subsurface soils of each quadrat and analyze differences among treatment and quadrats using chi-square analysis (SAS Inst., Inc. 1985). Data were also compared to results of a study examining lead shot availability in Halowell Reservoir in 1992 (Moser 1992) using chi-square analysis.

D. Summary of findings.

We found 26 (out of a possible 128) core samples to contain shot. Within these core samples we found a total of 30 lead pellets, compared to 26 lead pellets found by Moser (1992). Number of lead pellets found did not differ from those found in 1992 ($X^2 = 0.95$, $P = 0.33$). There was no difference in number of lead pellets found in quadrats 1, 2 and 3 between years, however we did find more lead pellets in quadrat 4 compared to the number found in 1992 (Figure 2). We found more lead pellets in the surface soils (top 5.1 cm) than in 1992 (Moser 1992) ($X^2 = 13.1$, $P < 0.01$; Figure 3).

E. Conclusions and recommendations

Overall, we observed little evidence of lead shot subsidence through surface soils at Halowell Reservoir. Surprisingly, we found more lead shot in the surface soils than was found 16 years earlier, despite the area having been closed to hunting and the nationwide ban on use of lead shot for waterfowl hunting. We attribute this apparent increase in lead shot availability in surface soils to inappropriate sampling design. We used the same sampling design (random transects) as Moser (1992) because we wanted to directly compare results of the two studies. However, because hunter distribution is rarely random within a wetland, lead shot is likely to be non-randomly distributed as well. Generally, wildlife-user groups occur in clusters (Garton et al. 2005), therefore it is likely that lead shot dispersed by waterfowl hunters also occurs in a clustered distribution. A better and more consistent method of assessing lead shot availability to waterfowl would be a clustered sampling design. Differences in lead shot found in 1992 and 2009 may also be attributed to pellet recovery rates. Moser (1992) estimated a pellet recovery rate of 77%; whereas our study had a 100% recovery rate.

Lead shot concentrations in excess of 20,000 pellets/acre (1 pellet per 2 square feet) were considered dangerous to waterfowl populations by Anderson and Havera (1989) and concentrations of 8,712 pellets per acre were considered "available in quantity " to waterfowl by Jessen and Lound (1959). Based on our estimates, lead pellet densities in the surface soils of Halowell Reservoir (62,111/acre) are above the level suggested as dangerous by Anderson and Havera (1989) and the level considered as "available in quantity" by Jessen and Lound (1959) for moderately hunted areas. We recommend active soil manipulation, including disking and plowing, of areas with lead shot prevalent in the surface soils to reduce lead shot availability to waterfowl and bring levels below those considered dangerous for waterfowl. Thomas et al.

(2001) concluded that deep tillage was more effective than shallow tillage in reducing lead shot near the surface and 2) plowing was more effective than disking for redistributing shot below the zone of availability for most waterfowl. We also recommend continued monitoring to evaluate the effects of active soil manipulation on lead shot distribution within Halowell Reservoir.

Results of this research were presented at the following meetings:

Arkansas Chapter of the Wildlife Society. Pine Bluff, Arkansas - April 2009.

International Meeting of the Society of Wetland Scientists. Madison, Wisconsin - June 2009.

Literature Cited

Anderson, W.L., and S.P. Havera. 1989. Lead poisoning in Illinois Waterfowl (1977-1988) and the implementation of nontoxic shot regulations. Illinois Natural History Survey Biological Notes 133.

Bellrose, F.C. 1959. Lead poisoning as a mortality factor in wildfowl populations. Illinois Natural History Survey Bulletin 27:235-288.

Esslinger, C.G and W.D. Klimstra. 1983. Lead shot incidence on a public goose hunting areas in southern Illinois. Wildlife Society Bulletin 11:166-169.

Flint, P.L. 1998. Settlement of Lead Shot in Tundra Wetlands. Journal of Wildlife Management 62:1099-1102.

Fredrickson, L.H., T.S. Baskett, G.K. Brakhage, and V.C. Cravens. 1977. Evaluating cultivation near duck blinds to reduce lead poisoning hazards. Journal of Wildlife Management 41:624-631.

Fredrickson, Leigh H. and T. Scott Taylor. 1982. Management of Seasonally Flooded Impoundments for Wildlife. USFWS Resource Publication 148. 30 pp.

Fredrickson, Leigh H. 1991. Strategies for Water Level Manipulations in Moist-soil Systems Leaflet 13.4.6. in Cross, D.H., compiler, 1988-1993, Waterfowl Management Handbook: U.S. Fish & Wildlife Service, Fish and Wildlife Leaflet 13.

Garton, E.O., J. T. Ratti, and J. H. Giudice. 2005. Reseach and Experimental Design. Pages 43-71 *in* C. E. Braun, editor. Techniques for wildlife investigations and management. Sixth edition. The Wildlife Society, Bethesda, Maryland, USA.

Hohman, W.L., J.L. Moore, and J.C. Franson. 1995. Winter survival of immature canvasbacks in inland Louisiana. Journal of Wildlife Management 59:384-392.

Jessen, R. and R. Lound. 1959. Study of incidence of lead shot in certain marshes and lakes. Pittmann-Robertson Job Completion Rep. Minn. W-11-R-19, Job #10.

Moser, T. 1992. Final Report on lead shot prevalence in Halowell Reservoir soils. AGFC Memo: September 9, 1992. 13pp.

Mudge, G.P. 1984. Densities and settlement rates of spent shotgun pellets in British wetland soils. Environmental Pollution (Series B) 8:299-318.

Sanderson, G.C., H.W. Norton, and S.S. Hurley. 1981. Effects of ingested lead-iron shot on mallards. Illinois Natural History Survey Biological Notes 116.

Schranck, B.W. and G. R. Dollahon. 1975. Lead shot incidence on a New Mexico public hunting area. Wildlife Society Bulletin 3:157-161.

White, D.H. and R. C. Stendell. 1977. Waterfowl exposure to lead and steel on selected hunting areas. Journal of Wildlife Management 41:469-475.

Wycoff, R.G., D.W. Wills, and L.L. Glasgow. 1972. An evaluation of recovery data from artificially seeded lead shot on Catahoula Lake, LaSalle Parish, Louisiana. Proc. Annu. Conf. Southeast. Assoc. Fish Wildl. Agencies 25:P245-254.

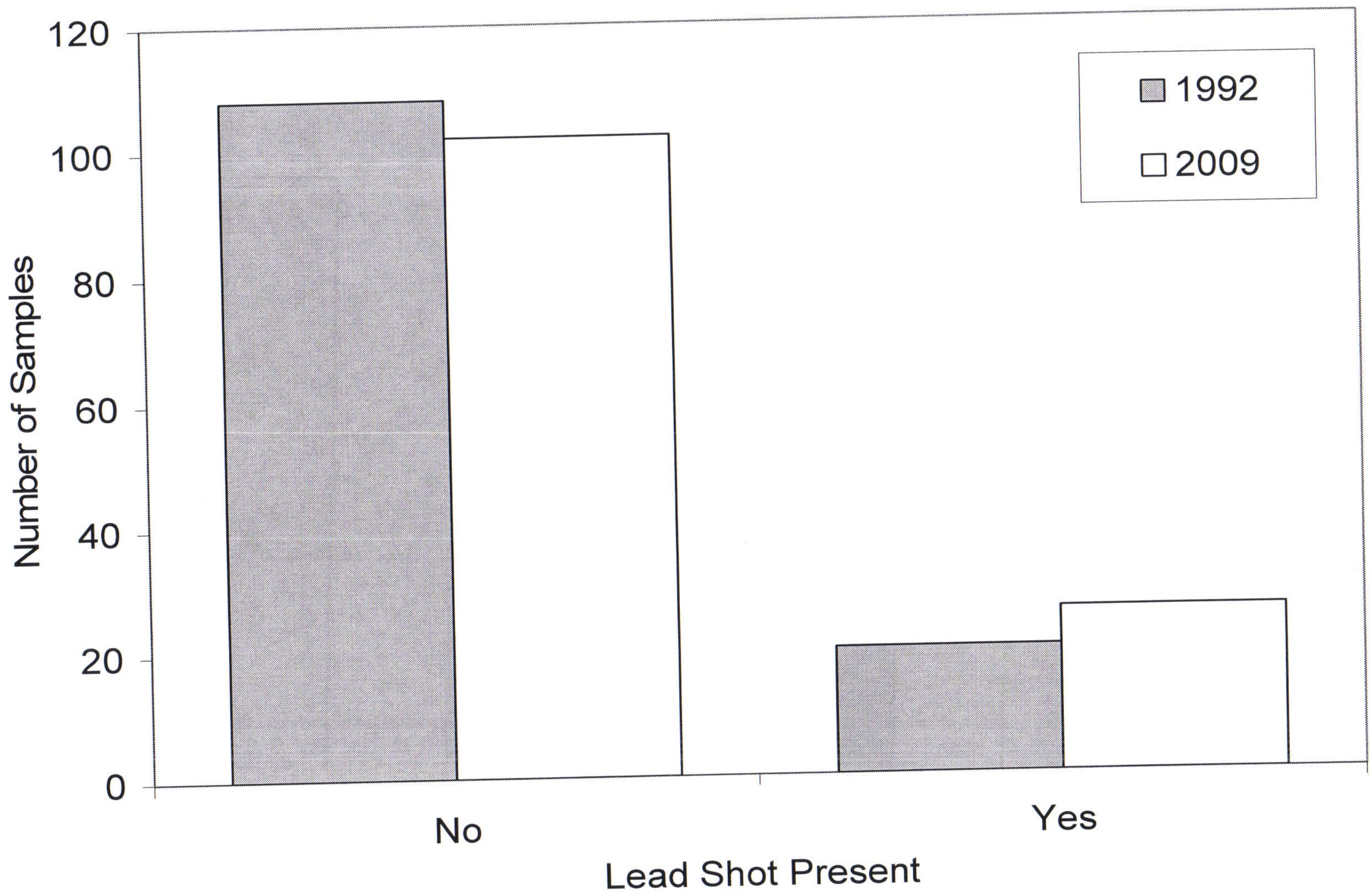

Figure 1. Comparison of core samples collected at Halowell Reservoir in which lead shot was present and absent in 1992 and 2009.

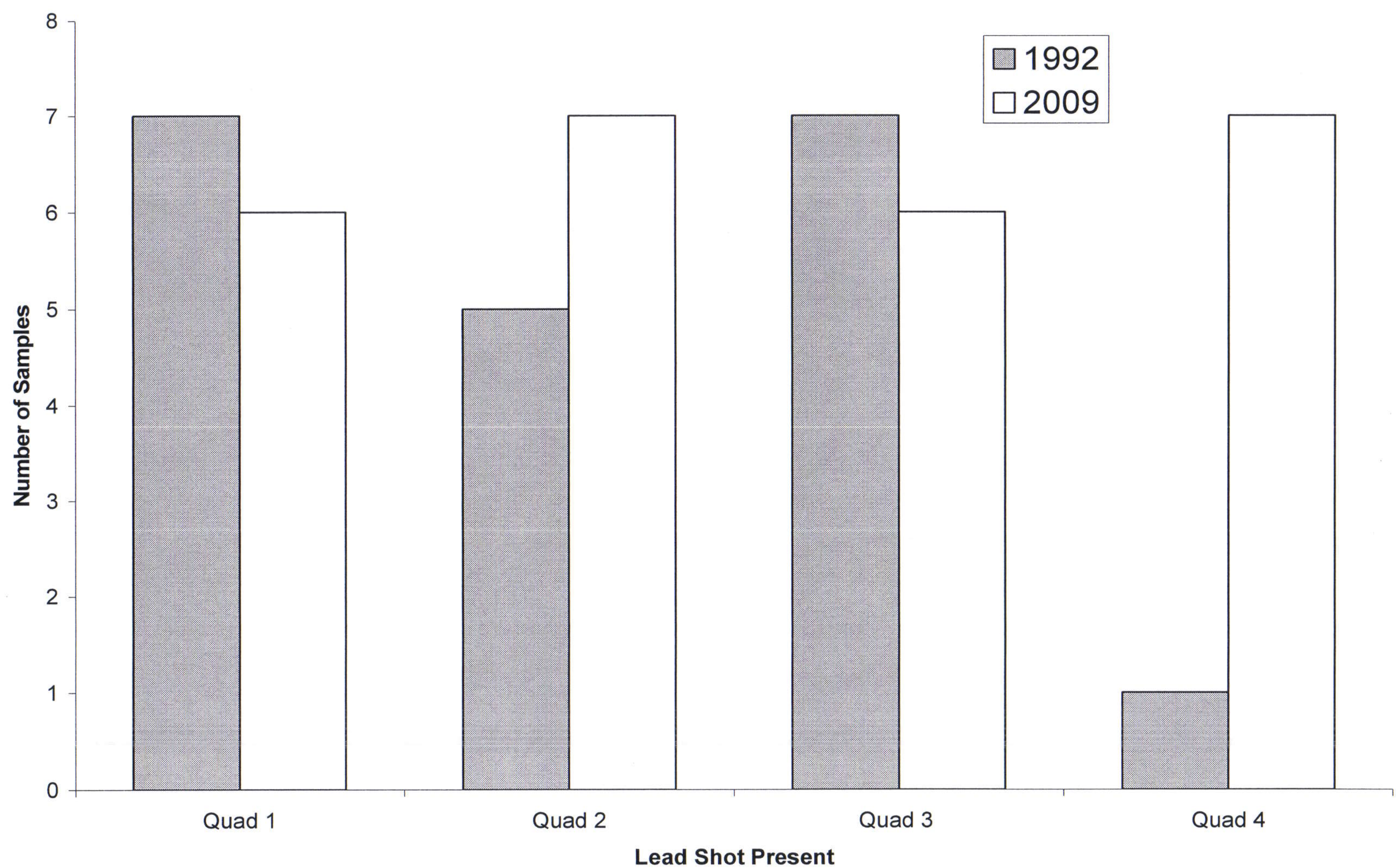

Figure 2. Comparison of lead pellets collected at Halowell Reservoir within 4 quadrarants in 1992 and 2009.

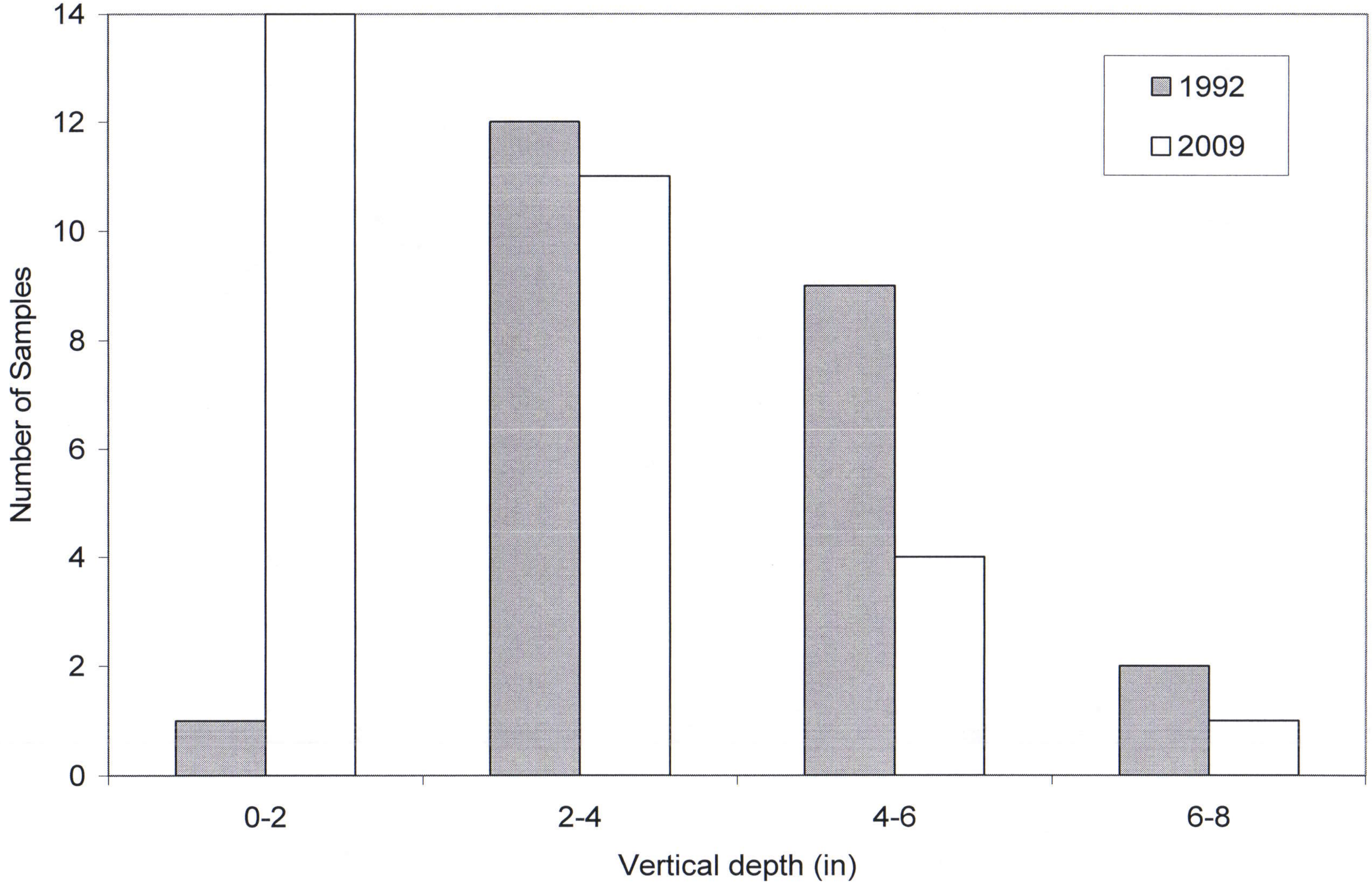

Figure 3. Comparison of lead pellets collected at Halowell Reservoir at 4 vertical depth ranges in 1992 and 2009.