Evidence for and Consequences of Deer Harvest Data Biases

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Abstract: Harvest data constitute an important source of information for the deer manager, but interpretation can be complicated by reporting bias, hunter selectivity, differential vulnerability, and aging errors. Daily harvest records for > 165,000 white-tailed deer (*Odocoileus virginianus*) taken during 1979–85 Illinois firearm seasons were examined for evidence of bias. Antlered males were apparently killed at a higher rate than other classes of deer; consequently, they became relatively less numerous in the herd and in the harvest as the season advanced. Yearling males, in particular, were highly vulnerable early in the season. Declining availability of antlered males and reduced hunter selectivity shifted pressure toward fawns and females as the season progressed. Fawns were apparently underrepresented in the total harvest but not the antlerless harvest. Male fawns were more vulnerable than their female cohorts. Biases involving various sex-age classes can affect calculation of certain population parameters from harvest data. The tendency toward increased representation of females with increased harvest intensity has implications for balancing recreational and population goals.

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Most deer herds in the United States are managed principally by regulation of sport hunting. Data from these harvests constitute the manager's primary source of information regarding the status of exploited populations. Whether such data are analyzed intuitively or used as input or verification for predictive models, a basic assumption is that demographic characteristics of the harvest are representative of the target population. This assumption may be incorrect to varying degrees because of a number of factors including hunter selectivity, reporting bias, differential vulnerability, and incorrect age determination of harvested animals (Burgoyne 1981). The importance of harvest data to modern deer management and the lack of consensus among biologists regarding form and cause of biases justify further research (Coe et al. 1980).

Our study examined daily harvest records for > 165,000 white-tailed deer (*Odocoileus virginianus*) taken in Illinois from 1979 through 1985 for evidence of seasonal change in sex/age composition. Computer simulations were used to investigate possible causes of observed patterns including availability, differential vulnerability, and hunter selectivity. Implications of biased harvest data are discussed.

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Methods

Firearm deer hunting in Illinois is conducted during 2 3-day seasons approximately 3 weeks apart each autumn. Permits are issued on a county quota basis for the entire 6-day period and allow individuals to take 1 deer of any sex or age. Successful hunters are required to bring their deer to a designated check station where each animal's sex and estimated age based on tooth replacement and wear (Severinghaus 1949) from jaws viewed *in situ* are recorded. To minimize the effect of aging errors, we used only 3 age classifications: fawns (0.5 years), yearlings (1.5 years), and adults (≥ 2.5 years). Data were combined for all years and management regions after preliminary analyses indicated no significant annual or geographic variation in trends. Inferential statistics were not used because the entire population of interest (all harvested deer) was represented.

Change in daily harvest composition was interpreted as evidence of differential rates of harvest among the cohorts involved, the rationale being that different removal rates alter composition of the surviving herd and thus also alters subsequent harvests (Hickey 1955, Pimlott 1959, Coe et al. 1980). It was assumed that direction of change in cumulative harvest ratios was toward prehunt conditions (Eberhardt and Blouch 1955). More sophisticated methods of analyzing harvest data for evidence of differential vulnerability (Paloheimo and Fraser 1981, Boer 1988, Fryxell et al. 1988) were not attempted because accurate age determination beyond the yearling class could not be assumed.

Monte Carlo simulations were used to obtain combinations of vulnerability and selectivity factors that produced daily harvests consistent with those observed. Each sex-age class was assigned daily coefficients of vulnerability and selectivity ranging from 0.4 to 1.0 (1.0 indicating maximum vulnerability and desirability). A hypothetical prehunt population of 100,000 deer consisted of 38.0% fawns (52 males:48 females); 27.5% yearlings (49 males:51 females); and 34.5% adults (40 males:60 females). Simulations were begun by randomly selecting an individual animal from the sex-age distribution. A hunter-deer encounter was determined stochastically based on that particular sex-age class's daily vulnerability factor. If an encounter occurred, harvest or escape was determined stochastically based on the animal's selectivity factor for that day. Harvested animals were removed from the prehunt population, unharvested animals were returned to it. The process was repeated until one-third of the prehunt population was "harvested." Relative daily harvests were proportional to the Illinois data.

The combinations of vulnerability and selectivity factors that could have produced the observed harvest pattern are extremely large, especially considering that final harvest also depended on preharvest herd composition and overall harvest rate, both unknowns in this case. Therefore, simulations were not intended to quantify vulnerability and selectivity factors; rather, the intent was to derive possible scenarios consistent with observed results and general knowledge of deer and hunter behavior.

Results

Composition of daily harvests changed throughout the 6-day season (Table 1). Representation of antlered males declined progressively from 48.8% on opening day to 25.6% on the last day. This change was particularly evident for yearling males which comprised 28.0% of the first day's harvest, but only 13.2% of the last day's kill. In contrast, there was increased representation of fawns (29.5% to 42.2%) and does (21.7% to 32.2%) as the season advanced. The above changes in harvest composition resulted in instability of various computed sex-age ratios (Table 2). Specifically, harvest sex ratios (M:F) declined among all age classes; yearling:adult age ratios declined for both sexes, and fawn:doe ratios increased within seasons but declined between seasons.

Discussion

Antlered males tend to predominate in early harvests (Severinghaus and Cheatum 1956) with a corresponding progressive increase in representation of females (White and Banasiak unpubl. rep., Northeast Wildl. Conf., Monticello, N.Y.,

Table 1. Daily composition (%) of white-tailed deer harvests during Illinois firearm seasons, 1979–85.

Sex-age class	Day of season						Total
	1	2	3	4	5	6	
Male fawn	18.1%	20.4%	21.9%	20.3%	21.5%	21.3%	20.0%
Female fawn	11.4	13.4	14.9	17.3	19.5	20.9	14.5
Male yearling	28.0	23.4	21.1	16.3	13.9	13.2	22.2
Female yearling	10.4	11.4	11.9	13.7	13.4	13.5	11.7
Male adult	20.8	18.1	16.7	14.0	13.1	12.4	17.5
Female adult	11.3	13.3	13.5	18.4	18.6	18.7	14.1
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
N	57,287	38,072	24,923	16,306	14,136	14,380	165,104

Table 2. Daily and cumulative change in white-tailed deer harvest sex-age ratios during Illinois firearm seasons, 1979–85.

Ratios[a]	Day of season 1	2	3	4	5	6
Male fawns : female fawns	158(158)[b]	151(155)	148(153)	118(148)	110(143)	102(138)
Male yearlings : female yearlings	268(268)	206(242)	178(228)	120(212)	103(200)	97(190)
Male adults : female adults	185(185)	136(163)	123(154)	76(141)	71(132)	66(125)
All males : all females	202(202)	163(185)	148(176)	103(165)	94(156)	88(148)
Fawns : doe	136(136)	137(137)	145(138)	117(135)	128(134)	131(134)
Yearling males : adult males	134(134)	129(133)	126(131)	117(130)	106(129)	106(127)
Yearling females : adult females	93(93)	85(89)	88(89)	74(87)	72(85)	72(83)

[a]X : 100Y.
[b]Daily (cumulative).

1962, Roseberry and Klimstra, 1974, Holbrook 1986, this study). Our simulations suggested that this pattern was due primarily to a seasonal decline in availability of males following initial disproportionate harvest coupled with (and related to) an initial negative bias against fawns and females that diminished as the season progressed. The final percentage of antlered males in the harvest (39.7%) probably overestimated relative abundance as evidenced by failure of their cumulative representation to stabilize by season's end.

Vulnerability of males is thought to increase during the rut (White and Banasiak unpubl. rep., Northeast Wildl. Conf., Monticello, N.Y., 1962, Coe et al. 1980); indeed, that is a basis for the timing of most hunting seasons. Field studies have shown that movement (Downing and McGinnes 1976) and observations (Hawkins and Klimstra 1970, Downing et al. 1977) of males tend to increase during the rut. Nevertheless, Van Etten et al. (1965) and Downing et al. (1966) noted that hunters saw fewer bucks than existed in enclosed populations; Van Etten et al. (1965) concluded that " . . . bucks might be a little less vulnerable than does." The popular notion of the wary old trophy buck may have some basis; however, most males taken by hunters are young animals (56% of the Illinois antlered harvest were yearlings and 84% were animals estimated to be $\leq$ 2.5 years old). Despite Hayne and Eberhardt's (unpubl. rep., 14th Midwest Wildl. Conf., Des Moines, Ia,. 1952) earlier opinion, the general consensus is that young males are more vulnerable than older bucks, at least early in the hunting season (Maguire and Severinghaus 1954, Dasmann and Taber 1956, Roseberry and Klimstra, 1974, McCullough 1979, this study). At the start of hunting, yearling males are the most inexperienced cohort not under maternal influence. In addition, they are socially subordinate, often transient, and likely to be occupying relatively unfamiliar habitat (Roseberry and Klimstra 1974). This behavioral vulnerability, coupled with positive hunter selection, probably accounts for the very high early harvest of this group. The possibility of a seasonal increase in wariness of young males, as noted elsewhere (Maguire and Severinghaus 1954, Roseberry and Klimstra 1974), was suggested by the simulations.

Possible biases involving fawns in any deer harvests are unclear from the literature (Coe et al. 1980). Gill (unpubl. rep., 9th Northeast. Wildl. Conf., Bretton Woods, N.H., 1953) and Van Etten et al. (1965) considered them the most vulnerable of all age classes. Nixon (1970) reported that fawn:doe harvest ratios appeared representative in Iowa but too high in Ohio. Eberhardt (1960), in contrast, thought that fawns were underrepresented in Michigan harvests. These conflicting findings may reflect Maguire and Severinghaus' (1954) contention that hunter selectivity is the determining factor in fawn harvests. Such selectivity undoubtedly varies regionally according to traditions, and seasonally with changing opportunities. Increased daily representation of fawns in the Illinois harvest probably reflected reduced availability of more desirable targets (especially yearling males) and a corresponding decline in hunter selectivity.

The fact that cumulative percentage of fawns was still increasing at season's end suggested that they were underrepresented in the total harvest. In contrast, harvest fawn:doe ratios were relatively stable over time and thus may have been more representative of prehunt conditions. In autumn, antlerless deer exist in small family groups which consist of several generations of does and their fawns (Hawkins and Klimstra 1970), and which are usually led by an adult doe (Coe et al. 1980). This social pattern would seem to make older females more vulnerable as they would tend to be the first animal seen by hunters and would be desirable because of size. However, hunting and orphaning can disrupt normal behavior, in which case, fawns might become more vulnerable and thus partially offset negative selection. The slight increase in fawn:doe ratios within seasons and the decline between seasons undoubtedly reflected subtle interactions of vulnerability and selectivity of both groups. However, these factors apparently balanced to the point where overall harvest fawn:doe ratios were fairly representative of prehunt conditions, as evidenced by their relative stability over time. One aspect of fawn harvest seems clear. Males are more vulnerable than females (Roseberry and Klimstra 1974, Coe et al. 1980, this study), presumably because of their more active, venturesome nature (Taber and Dasmann 1954, Klein 1970).

A puzzling aspect of many doe harvests is an apparent underrepresentation of yearlings. The fact that female:male ratios are often lower in yearlings than adjacent age classes can be explained partially by the previously discussed heavy harvest of yearling males. However, it is common for 2.5-year-olds to numerically exceed yearlings in female harvests (White 1968), which is a virtual demographic impossibility (Dapson et al. 1981). One explanation is that yearlings are somehow less vulnerable than older does, which more often have the responsibility of an attending fawn (Laramie and White 1964) or for leading the family group (Coe et al. 1980). Maguire and Severinghaus (1954), however, found no evidence of differential wariness among does during New York harvests. Our finding of a slight seasonal decline in the yearling:older doe ratio suggested that younger females were somewhat more, not less vulnerable. Dapson et al. (1981) blamed the phenomenon of "missing" yearlings on aging errors. Data from a Pennsylvania deer herd (Woolf and Harder 1979, unpubl. data) showed the problem to be less apparent when age determination was by professional examination of clean, excised jaws rather than by trained laymen viewing jaws *in situ*. Apparent discrepancies in Illinois harvests may not have involved a shortage of yearlings, but rather an artificial inflation of the 2.5-year-old age class due to aging errors (Roseberry 1980). Gill (unpubl. rep., 9th Northeast Wildl. Conf., Bretton Woods, N.H., 1953) also noted instances of seeming excess of this 2.5-year-old cohort in several state doe harvests.

Implications

Biases and temporal changes in harvest structure evident from this and other studies have implications for use of harvest data and for impact of the harvest itself. For example, male harvest age structure is sometimes used to estimate survival (Lang and Wood 1976, Downing 1980, Burgoyne 1981). Under certain circumstances, overrepresentation of yearlings, which apparently occurred in the Illinois harvest, could overestimate mortality rates. This would most likely occur in lightly hunted populations in which prehunt age structure had not been altered greatly by differential harvest. If, however, hunter harvest constituted the bulk of annual losses, and prehunt age structure reflected differential harvest, then mortality estimates of the yearling class using harvest data would be less biased.

Several current systems for monitoring herd trends (Lang and Wood 1976, Dickinson 1982, Creed et al. 1984) incorporate Severinghaus and Maguire's (1955) method of determining adult sex ratios based on the proportion of yearling males and females in their respective harvests. Overrepresentation of yearling males in relation to yearling females would result in overestimation of adult females/adult male. Calculation of adult sex ratio by this method requires equal recruitment into the yearling class, hence the ratio is often "corrected" for a suspected preponderance of males by multiplying it by female fawns/male fawn. If this fawn sex ratio is obtained from harvest data, the typical bias toward males would act to lower estimated adult females/adult male. In heavily hunted populations, however, the disproportionate harvest of male fawns may, in fact, tend to equalize recruitment into the yearling class thus making the "correction" unnecessary.

Harvest fawn:doe ratios also should be interpreted with caution. Fawn harvest may be influenced by hunter selectivity, which can vary regionally and seasonally. One use of harvest data that would be relatively unaffected by bias is comparison of current and past harvest composition for the purpose of identifying "strong" or "weak" cohorts in the population. Such information would be useful for interpreting recent environmental or biological events as well as predicting near future herd trends.

Most white-tailed deer herds are relatively unaffected by the harvest of males, but are quite sensitive to the harvest of females (Anderson et al. 1974). Therefore, the tendency for cumulative representation of females to increase as the season progresses has important implications for harvest management. In effect, relative impact on the female segment (and thus on herd dynamics) may increase exponentially as hunting pressure increases linearly. It should not be overlooked, however, that seasonal changes in harvest composition, if predictable, increase the deer manager's options for balancing population/recreation goals through manipulation of hunting regulations (Roseberry and Klimstra 1974).

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