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Abstract: To develop a correction matrix useful for adjusting errors in data collected at mandatory hunter registration stations, white-tailed deer (*Odocoileus virginianus*) age and sex classification data were collected in southern and western Minnesota during 1982-1983 and 1988. During 1982-1983, of 1,928 deer registered 285 (14.8%) were incorrectly classified. Results indicated that hunters incorrectly classified white-tailed deer by age and sex: adult males (1.3%), adult females (3.9%), fawn males (25.7%) and fawn females (44.6%). During 1988, of 1,566 deer registered 214 (13.7%) were incorrectly classified. Hunters incorrectly classified adult males (1.8%), adult females (5.8%), fawn males (38.8%) and fawn females (45.3%). An inverse correction matrix was developed for both sampling periods. To improve the accuracy of classifying the harvest data by age and sex, the 1982-1983 correction matrix generated from this study was applied to Minnesota's 1984 deer registration data. Harvest data are the primary information used for population modeling and determining harvest season regulations in farmland Minnesota. Additionally, both matrices (1982-1983 and 1988) were used to correct the 1988 farmland zone harvest data by age and sex and the results were compared. Correction matrices can be utilized to improve accuracy and provide inexpensive estimates of age and sex classifications. Five types of errors that may have contributed to registration errors are discussed.

Since 1972, the Minnesota Department of Natural Resources (DNR) has collected white-tailed deer (*Odocoileus virginianus*) harvest data at mandatory deer registration stations. Deer registration stations (e.g., gas stations, convenience stores, and lockers) were operated by private citizens not trained in deer aging and sexing techniques. Hunters detached a stub from their hunting license and exchanged it for a transport tag at the registration station. The registration station operator marked a box on the registration stub indicating whether the deer was an adult male, adult female, fawn male, or fawn female. Operators seldom examined deer to verify hunter's identification of age and sex.

Karns (1974) verified that determination of age and sex at Minnesota registration stations was subject to error and hypothesized that error rates may vary between regions of the state. Age and sex data from hunter registration must be adjusted for registration bias before it is used for population modeling and determining harvest season regulations. Registration bias can be evaluated on a subsample of the registration data by trained personnel at deer registration stations by simultaneously evaluating age and sex determinations made by hunters. Our objective was to develop a registration error correction factor derived from simultaneous age and sex determinations at hunter registration stations that could be used for population modeling and determining harvest season regulations in farmland Minnesota.

This study was conducted with assistance of DNR Section of Wildlife personnel. We thank J. R. Ludwig and A. H. Berner who were instrumental in devising the survey and D. M. Heisey for his advice on the statistical analysis. We thank A. H. Berner, R. O. Kimmel, D. E. Simon, and R. Lake for their comments on earlier drafts of this manuscript.

METHODS

DNR personnel with experience in deer age and sex identification collected deer teeth and aged and sexed white-tailed deer at 6 mandatory deer registration stations in Big Woods Southeast Deer Management Subunit (DMSU) in 1982, 15 stations in Prairie River, Prairie Southwest, Prairie Southeast, Big Woods Metro, and Big Woods Central DMSUs in 1983, and 16 stations in all DMSUs except Red River West and Big Woods Metro in 1988 (Fig. 1). To maximize the sample, registration stations with large numbers of deer registered in previous years were selected for the study.

During the study, Minnesota had 5 deer hunting zones with varied regulations. In 1982, the study was conducted in Zone 3 which had a 9-day buck-only season followed by a 3-day buck or antlerless-deer-by-permit season. In 1983, the study was conducted in Zone 4 which had a 3-day buck-only hunt followed by a 2-day season for buck or antlerless-deer-by-permit. In 1988, the study was conducted in Zone 3 and Zone 4. Zone 3 now had a 9-day buck-only season followed by a 7-day buck or antlerless-deer-by-permit season. Zone 4 now had a 2-day antlerless-deer-by-permit season followed by a 4-day antlerless-deer-by-permit season. The study was conducted on the first 2 days of the antlerless-deer-by-permit seasons.

Upon arrival at deer registration stations, hunters registering deer were asked if DNR personnel could remove the deer's front incisors for aging; in 1982 and 1983 a shoulder patch was offered to the hunter as an incentive. The hunter was then instructed to register deer with the registration station operator. The registration station operator registered deer inside the station by collecting the hunter's license stub, recording deer age and sex (usually relying on hunter's classification), if necessary inspecting the antlerless permit, and presenting hunter with a transport tag to be affixed to the deer. Operators rarely inspected deer.

During the time the hunter was completing registration inside the station, a DNR employee remained outside the registration station and extracted the front incisors, determined sex by appearance of antler growth and/or genitalia, and distinguished fawns from adults by tooth replacement and wear (Severinghaus, 1949). The DNR employee discreetly recorded the above information in addition to the hunter's license number which was printed on the hunting license, possession tag, and registration stub.

At close of registration each day, Minnesota DNR Section of Wildlife personnel inspected registration stubs and recorded the registration station operator's data. Therefore, two classifications were collected for each deer: 1) age and sex determination by the normal registration procedure, and 2) age and sex determination conducted by DNR personnel.

To insure that method of sampling would have minimal bias, DNR personnel were instructed to act casually and not give the impression they were evaluating the registration procedure. Registration station operators and hunters were instructed to register deer by their normal procedures. Prior to registering their deer, hunters were not informed of their deer's age or sex. Furthermore, to prevent hunters and registration station operators from being aware the registration procedure was being evaluated, all information was discreetly recorded by the DNR employee.

One method often used to analyze data and apply correction factors assumes that populations sampled have identical age and sex compositions. For example, given the matrix derived from concurrent sex/age classifications, and given a new set of error-prone data (S_{obs}, T_{obs}, U_{obs}, V_{obs}) observed by registration station harvest classification, the estimate of adult

	Registration Stub Classification				'True' Classification[a]
Age/Sex	Adult Male	Adult Female	Fawn Male	Fawn Female	
Adult Male	a	b	c	d	W
Adult Female	e	f	g	h	X
Fawn Male	i	j	k	l	Y
Fawn Female	m	n	o	p	Z
Registration Total	S	T	U	V	

[a]Age and sex classification determined by Minnesota DNR personnel.

males adjusted by the registration bias matrix W_{adj} would be calculated from proportions of registration totals that were correctly registered in this study.

However, the above is the sum of proportions of actual age and sex classifications in the subsample multiplied by the observed values. Therefore, the adjusted value depends on the proportion of age and sex class in the sample (e.g., a/S is the proportion of registered adult males that were actually adult males, thus $[a/S]*S_{obs}$ depends on the proportion of adult males in the sample). This method is only useful for adjusting a sample of registration data with similar proportions of actual sex/age classifications as the subsample used to create correction factors.

However, actual sex and age proportions usually differ in harvested populations. MacDonald and Dillman (1968:123) compared a mail survey of deer hunters with a parallel data set of their known performance and noted that interpretation of data depended upon the actual relative proportion of age and sex classes harvested. A more precise method of analysis is required for adjusting data of other populations. This can be accomplished by deriving a correction matrix (Hoenig and Heisey 1987) from analysis of proportions of "true" (i.e., determined by DNR biologists) age and sex classifications that were correctly registered by hunters.

Thus, a new set of error-prone deer registration data can be adjusted by an inverse matrix developed from this study, regardless of sex/age class proportions. To determine the correction matrix needed to transpose errors, data were classified and entered in cells. From analysis of proportions of DNR-determined age and sex classifications that were incorrectly registered (Table 1), a correction matrix (Table 2) was generated by inverting the matrix (Hoenig and Heisey 1987). This technique can be used to adjust individual registration data to obtain harvest estimates, which are essential for accurate population modeling efforts.

Data analysis was conducted with a computer spreadsheet. A chi-square goodness of fit test was used to test if data from DMSUs could be pooled.

RESULTS AND DISCUSSION

Concurrent age and sex classifications were obtained for 638 deer at 6 selected registration stations in 1982 and 1,290 deer at 15 selected registration stations in 1983. No difference between error classification matrices was noted among the 6 DMSUs ($X^2 = 76.8$, $df = 60$, $P = 0.071$). Therefore, for 1982-1983 pooling of DMSUs is a reasonable method of developing a correction matrix useful for adjusting farmland deer harvest estimates (Tables 1, 2).

Concurrent age and sex classifications were obtained for 1,566 deer at 16 registration stations in 1988. No difference between error classification matrices was found among the 9 DMSUs ($X^2 = 99.1$, $df = 96$, $P = 0.394$). Therefore, for 1988 pooling of DMSUs is a reasonable method of developing a correction matrix useful for adjusting farmland deer harvest estimates (Tables 3, 4).

During 1982-1983, hunters incorrectly registered 285 (14.8%) deer. Female fawns were incorrectly registered most often (44.6%) followed by male fawns (25.7%). Very few errors were made in registering adult males (1.3%) or adult females (3.9%). Hunter registration underestimated number of fawns harvested by 24.5% and overestimated number of adult females by 22.2%. Similarly in 1988, hunters incorrectly registered 214 (13.7%) deer. Female fawns were incorrectly registered most often (45.3%) followed by male fawns (38.8%). Very few errors were made in registering adult males (1.8%) or adult females (5.8%). During 1988, hunters underestimated number of fawns harvested by 21.9% and overestimated number of adult females by 18.8%.

Our observations suggest that registration errors most likely resulted from:

1. Hunter erred or falsified the sex/age identification of harvested white-tailed deer. This may be due to peer pressure. Many hunters feel embarrassed by shooting a young deer and may register their deer as an adult to avoid admitting they shot a fawn.
2. Antlerless deer were incorrectly classified as a "doe" by hunters and thereby registered as females because antlerless permits are incorrectly known as 'doe permits' rather than 'either sex' permits.
3. In cases where the registration operator inspects deer, the operator erred or falsified sex/age identification of harvested white-tailed deer.
4. Hunters tagged a deer shot by another member of the hunting party. In this situation the hunter may not be aware of what another member shot and what he actually tagged.
5. Random recording errors by registration station operators or DNR personnel. In southern and western Minnesota, over 90% of adult males have antlers with 4 or more points. If many of the errors were truly random, some adult bucks would have been classified as female fawns. When combining periods 1982-1983 and 1988, only one adult male was identified on registration stubs as a female fawn (Tables 1, 3), thus few mistakes were probably made as a result of random errors.

The inverse correction matrix generated from pooled 1982-1983 study data (Table 2) was used to adjust the tally of 62,265 deer registered during the 1984 antlerless season in farmland Minnesota (Table 5). To apply the correction matrix, registration stub data totals were multiplied vertically within the matrix and cells added horizontally to produce corrected classifications of sex and age.

Results of applying the 1982-1983 correction matrix to the 1984 farmland deer registration data indicates that hunters under-reported the number of fawns harvested by 23.8%, over-reported number of adult females by 18.9%, and over-reported the proportion of males (55.1%) in the fawn harvest (adjusted proportion = 51.2%; Table 5). Within individual registration blocks, the magnitude of difference among registration data and adjusted figures was much greater.

Because misclassification of fawns was a common classification error, registration errors varied with percentage of fawns in the harvest. Similarly, other studies have documented a large error rate of fawn identification. In northern Minnesota, Karns (1974) showed that deer hunter registration data underestimated fawn numbers by 24%, whereas in Nebraska, Trindle and Menzel (1985) demonstrated that hunter registration underestimated fawn numbers by 64%. Furthermore, hunter surveys compared with professional age and sex determinations at check stations noted that white-tailed deer fawns were underestimated by 54% (Smith 1959) and 26% (MacDonald and Dillman 1968).

Application of the 1988 error classification matrix (Table 4) to 1988 farmland registration data corrected the harvest totals of fawn males and fawn females by 41.0% and 1.3%, respectively (Table 6). Interestingly, the 1982-1983 matrix corrected the 1988 harvest totals for fawn males by 21.0% and fawn females by 39.8% and was significantly different than the correction by the 1988 matrix ($X^2 = 32.3$, df = 12, $\underline{P} < 0.001$). In 1988, hunters made more mistakes when registering male fawns.

From the above matrix corrections it appears that more fawn males were incorrectly classified in 1988, whereas more fawn females were incorrectly classified in 1982-1983 (Table 6). However, the ratio of male fawns to female fawns registered (i.e., in the harvest) did not change substantially from 1982-1983 (57.8%:42.2%; Table 1) to 1988 (52.2%:47.8%; Table 3). Adult males made up 42.7% of the deer registered in 1988 (Table 3) and 26.7% of the deer registered in 1982-1983 (Table 1), whereas adult females made up 27.9% of the deer registered in 1988 (Table 3) and 33.5% of the deer registered in 1982-1983 (Table 1). These comparisons suggest the source of primary error in hunter registration may not be an error in sex identification but an error of including fawns into the wrong age class.

Certain biases are inherent in our study. Because of DNR presence at registration stations, hunters may have been less inclined to provide incorrect age and sex information or the station operator may have altered his inspection routine. These biases were probably minimal compared to the magnitude of registration error and may have been partially self-canceling. This study was designed to minimize bias by not revealing the full intent to registration operators, inspecting registration stubs once at the end of each day, and informing operators the intent of stub inspection was only to count number of deer registered.

The 1988 correction matrix (Table 4) is only applicable to buck or antlerless-deer-by-permit seasons in farmland Minnesota. Changes in season format and/or hunter and registration station operator knowledge may require further study and the development of a new matrix. In other regions where spike antlers are common on adult deer, more errors in aging deer may occur.

MANAGEMENT RECOMMENDATIONS

Harvest data collection should be continued at mandatory registration stations and the correction matrix should be applied to adjust for registration bias. This technique provides a reasonable estimate of registration classifications and is the most cost-efficient method of acquiring this data. The registration correction matrix from this study should be applied to all buck or antlerless-deer-by-permit season harvest registration figures in farmland Minnesota for purposes of population modeling and determining harvest regulations. The study should be repeated at least every 10 years or whenever the hunting season format changes.

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Table 1. Age and sex classifications from selected farmland deer registration stations, Minnesota 1982-1983. (Correct age and sex registrations in parentheses).

	Registration Stub Classification				'True' Classification*
Age/Sex	Adult Male	Adult Female	Fawn Male	Fawn Female	
Adult Male	(514)	2	5	0	521
Adult Female	4	(645)	3	19	671
Fawn Male	33	39	(300)	32	404
Fawn Female	1	134	13	(184)	332
Registration Total	552	820	321	235	1,928

*Age and sex classification determined by Minnesota DNR personnel.

Table 2. Inverse matrix of age and sex classifications from selected farmland deer registration stations, Minnesota 1982-1983. Cell values multiplied by respective columns registration total and summed is equal to the 'true' classification[a].

	Registration Stub Classification				'True' Classification[a]
Age/Sex	Adult Male	Adult Female	Fawn Male	Fawn Female	
Adult Male	1.01473	-0.00597	-0.11156	0.00672	521
Adult Female	-0.00360	1.06329	-0.05566	-0.77040	671
Fawn Male	-0.01320	-0.00349	1.35853	-0.09337	404
Fawn Female	0.00207	-0.05383	-0.19132	1.85705	332
Registration Total	552	820	321	235	1,928

[a]Age and sex classification determined by Minnesota DNR personnel.

Table 3. Age and sex classifications from selected farmland deer registration stations, Minnesota 1988. (Correct age and sex registrations in parentheses).

	Registration Stub Classification				'True' Classification[a]
Age/Sex	Adult Male	Adult Female	Fawn Male	Fawn Female	
Adult Male	(669)	5	6	1	681
Adult Female	3	(437)	6	18	464
Fawn Male	12	42	(147)	39	240
Fawn Female	2	67	13	(99)	181
Registration Total	686	551	172	157	1,566

[a]Age and sex classification determined by Minnesota DNR personnel.

Table 5. Farmland Minnesota's 1984 deer harvest adjusted by age and sex using the inverse matrix of data collected at 21 farmland deer registration stations, Minnesota 1982-1983. Cell values multiplied by respective columns registration total and summed is equal to the 'true' classification[a].

	Registration Stub Classification				'True' Classification[a]
Age/Sex	Adult Male	Adult Female	Fawn Male	Fawn Female	
Adult Male	1.01473	-0.00597	-0.11156	0.00672	27,167
Adult Female	-0.00360	1.06329	-0.05566	-0.77040	18,472
Fawn Male	-0.01320	-0.00349	1.35853	-0.09337	8,514
Fawn Female	0.00207	-0.05383	-0.19132	1.85705	8,112
Registration Total	27,633	21,955	6,984	5,693	62,265

[a]Age and sex classification determined by Minnesota DNR personnel.

Table 6. Minnesota's 1988 farmland deer harvest data and the deer harvest data corrected by age and sex using the 1982-1983 matrix and the 1988 matrix.

	Adult Male	Adult Female	Fawn Male	Fawn Female
1988 Harvest data (raw)	36,903	24,834	7,608	5,923
1988 Corrected Harvest data using:				
1988 Matrix	36,808	21,730	10,729	6,001
(% change*)	(-0.3%)	(-12.5%)	(41.0%)	(1.3%)
1982-1983 Matrix	36,489	21,287	9,208	8,283
(% change*)	(-1.1%)	(-14.3%)	(21.0%)	(39.8%)

*Corrected from raw data.

Figure 1. Deer management subunits of farmland Minnesota, 1982-1983 and 1988.

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