Black Bear Population Estimates for New Jersey, 2003 and 2005

by

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I was provided capture data for bears tagged in New Jersey in 2003 and 2005 and whether these tagged bears were harvested during the hunting season of the same year. In addition, I was provided harvest data for all bears harvested in the New Jersey hunting seasons of 2003 and 2005. From the capture dataset I did not exclude tagged bears known to have died prior to the hunting season.

I used these data to then estimate abundance of black bears in New Jersey Bear Management Zones (BMZ) 1, 2, 3, and 4 for 2003 and 2005. I used the approach outlined by Diefenbach et al. (2004), which was developed using data from Pennsylvania's bear capture and harvest records.

I first developed a series of linear-logistic regression models to investigate whether the probability of harvest was related to age-sex class (cub, adult male, adult female), year, and BMZ. Diefenbach et al. (2004) found that age and sex were the two most important variables that described the variability in harvest rates of black bears in Pennsylvania. Based on the data provided for tagged bears, the proportion of bears harvested by age-sex class, BMZ, and year are provided in the tables below.

Table 1. Proportion of tagged bears harvested (and the number of tagged bears) for each age-sex class by bear management zone (BMZ) for New Jersey in 2003.

	Age-sex class		
BMZ	Cub	Adult male	Adult female
1	0.32 (37)	0.23 (27)	0.45 (52)
2	0.35 (6)	0.35 (6)	0.30 (5)
3	0.25 (28)	0.28 (31)	0.47 (52)
4	0.58 (11)	0.10 (2)	0.32 (6)

Table 2. Proportion of tagged bears harvested (and the number of tagged bears) for each age-sex class by bear management zone (BMZ) for New Jersey in 2005.

	Age-sex class		
BMZ	Cub	Adult male	Adult female
1	0.17 (18)	0.47 (51)	0.36 (39)
2	0.32 (9)	0.29 (8)	0.39 (11)
3	0.16 (20)	0.36 (44)	0.48 (60)
4	0.61 (8)	0.08 (1)	0.31 (4)

Tables 1 and 2 show that relatively few bears were tagged in BMZs 2 and 4. Also, in both years the proportion of adult females harvested tended to be greater than for males. The proportion of cubs harvested differed greatly between 2003 and 2005, in which harvest rates were much greater in 2003 for this age class.

The best model that explained the variability in harvest rates included age-sex class (cub, adult male, adult female), BMZ, year, and interaction terms for age-sex class and year. Parameter estimates for this model are provided in Table 3.

Table 3. Parameter estimates for a linear-logistic regression model to explain variability in harvest rates of bears, New Jersey, 2003 and 2005. The reference coding approach was used for the design matrix (see Diefenbach et al. 2004), in which adult females were the reference level for age-sex class and BMZ 4 was the reference level for BMZ.

Parameter	Level	Estimate	SE
Intercept		-1.2685	0.5485
Year	2003	0.0554	0.3124
Age-sex class	Cubs	-1.7519	0.6396
Age-sex class	Adult males	-0.4504	0.3428
BMZ	BMZ 1	0.5641	0.5276
BMZ	BMZ 2	0.1929	0.6433
BMZ	BZM 3	-0.2912	0.5418
Age-sex class × year	Cubs and 2003	1.4862	0.7245
Age-sex class × year	Adult males and 2003	-0.6429	0.5714

This linear-logistic model was used to estimate harvest probability in a Horvitz-Thompson type model (Diefenbach et al. 2004) to estimate the population size in BMZs 1-4 in 2003 and 2005.

Table 4. Population estimates for New Jersey in 2003 and 2005 for Bear Management Zones (BMZ) 1-4.

Year	BMZ	No. harvested	$\hat{N}$	$\hat{SE}(\hat{N})$	95% CI
2003	1-4	333	2,552	886.787	1,316 – 4,946
	1	161	728	181.098	450 – 1,177
	2	53	1110	746.767	335 – 3,677
	3	105	648	238.671	322 – 1,304
	4	14	66	30.118	28 – 155
2005	1-4	298	2397	739.658	1,328 – 4,329
	1	129	674	191.024	391 – 1,163
	2	58	1095	677.719	359 – 3,343
	3	103	595	203.944	309 – 1,143
	4	8	33	13.959	15 – 7 3

The population estimate for 2003 in this report will differ from what I provided previously because the model used here to estimate harvest rates was based on 2003 and 2005 data. Also, notice that the ratio of SE/ $\hat{N}$ is quite high for all estimates, which is because relatively few bears were tagged in some units and because harvest rates varied greatly between years, even for the same age-sex class and BMZ.

Also, I estimated population size by age-sex class (cubs, adult males, adult females; see Table 5). It is clearly evident that the number of cubs is underestimated, which means that harvest rates of tagged cubs was probably greater than the population overall.

Table 5. Population estimates for New Jersey in 2003 and 2005 for age-sex classes across Bear Management Zones 1-4.

Year	Age-sex class	No. harvested	$\hat{N}$	$\hat{SE}(\hat{N})$	95% CI
2003	Cubs	87	158	40.994	96 – 261
	Adult males	73	1,033	660.025	328 – 3,252
	Adult females	173	1,361	573.786	616 – 3,007
2005	Cubs	46	242	73.872	135 – 435
	Adult males	101	841	395.41	350 – 2,019
	Adult females	151	1,314	526.71	617 – 2,800

Summary

The precision of population estimates is poor. Harvest rates varied widely among management units, age-sex classes, and between years. In addition, relatively few bears were captured and tagged in BMZs 2 and 4. Consequently, the variability in harvest rates and relatively few bears tagged in some BMZs made it difficult to obtain statistically precise population estimates. Changes in point estimates of population size (from 2003 to 2005) in Tables 4 and 5 are meaningless because the statistical precision is too poor to detect changes in abundance.

Furthermore, I have no data to evaluate the assumptions of this population estimation technique, such as the assumption that bears do not emigrate or immigrate between the tagging and harvest periods. Also, note that bears known to have died prior to the hunting season were not excluded from this analysis, which means that the estimated abundance is greater than the number of bears alive immediately prior to the hunting season. Diefenbach et al. (2004) accounted for nonhunting mortality and tag loss by using month of capture as an explanatory variable such that they estimated the population size immediately prior to the hunting season; however, New Jersey has too few data to include this variable in a model. Excluding known mortalities will help remove the positive bias in the resulting population estimate, but because only a portion of nonhunting mortalities are identified the resulting population estimates are still positively biased some unknown amount. The resulting population estimate would be for some unknown date prior to the hunting season (see Diefenbach et al. 2004).

Finally, Diefenbach et al. (2004) noted that population estimates for breeding age females in Pennsylvania exhibited poor precision, biologically unrealistic variation in annual abundance, and likely were biased. This is because it is not possible to identify a covariate that can explain the probability a female bear is in the den and not available for harvest. Consequently, harvest rates for this segment of the population cannot be expected to be modeled with precision.

Literature Cited

Diefenbach, D. R., J. L. Laake, and G. L. Alt. 2004. Spatio-temporal and demographic variation in the harvest of black bears: implications for population estimation. *Journal of Wildlife Management* 68: 947-959.