Survival and hunter reporting rate estimates of mourning doves based on 2003-2013 Pennsylvania bird banding data[1]

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INTRODUCTION

Mourning doves (*Zenaida macroura*) are one of the most frequently hunted North American birds (KDWPT, 2014), and therefore it is important to obtain reliable estimates of annual survival and hunter reporting rates for effective population management. Mourning doves are widely distributed throughout North America and into Canada and Central America (Seamans and Sanders, 2014; Fig. 1); thus national-scale, robust data are available for much of their range. Mourning doves may reside in their breeding range throughout winter or migrate southward to Mexico and Central America (Aldrich, 1993), exposing these birds to various hunting practices or other threats. As survival and harvest rates likely vary based on distance traveled between summer and winter ranges and range of origin, regional analyses are important.

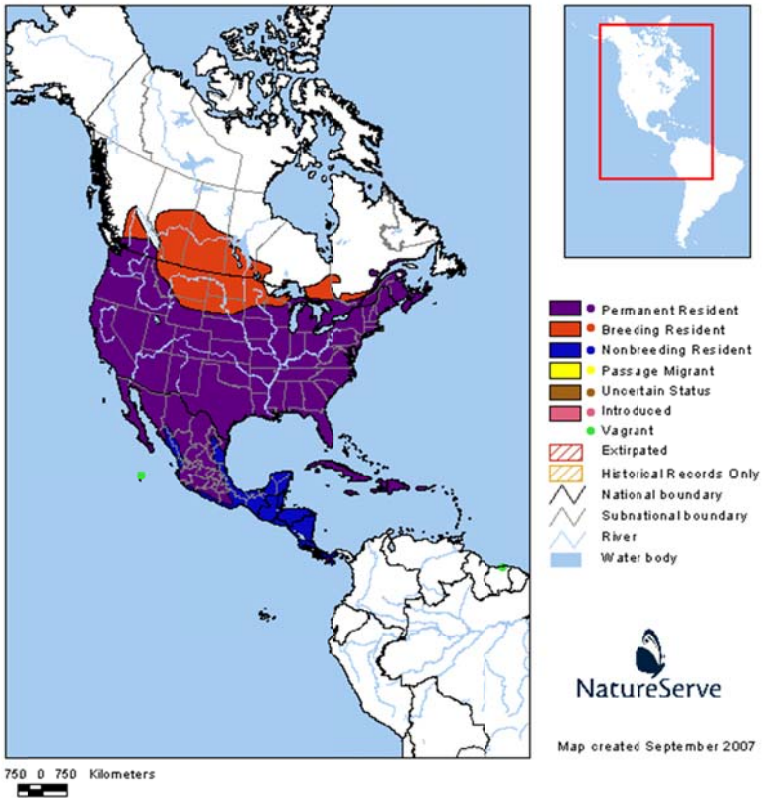

Figure 1: Mourning dove range map (NatureServe, 2007)

Mourning dove abundances have generally increased over the last 48 years in the eastern portion of the range, but in the last five years, abundance estimates were stable (Seamans and Sanders, 2014). Pennsylvania mourning dove populations appear stable based on recent assessments despite a significant increase in calling along survey routes reported in 2012 (Seamans and Sanders, 2012). To better inform managers and assess current practices, regular analysis of banding data should occur as data become available. The Pennsylvania Game Commission, via the U.S. Geological Survey's Bird Banding Lab, tracks mortalities of animals as reported by hunters (including year and cause of death) and records information about the sex (Male, Female, Unknown), age (Hatch Year [HY], After Hatch Year [AHY], Unknown), and region (Piedmont, Non-Piedmont) where animals are banded and harvested (see Methods for more details).

When modeling survival and reporting rates, better estimation of responses to hunting can be obtained by using demographic and regional information. Male and female survival and reporting rates are expected to be relatively similar due to shared parental duties (e.g. incubation and feeding) (Hitchcock and Mirarchi, 1984) and similar hunter harvest rates are likely because the sexes are indistinguishable in the field.. The primary difference between Piedmont and non-Piedmont regions is of primary importance for this report. This roughly represents the Northwest and Southeast portions of Pennsylvania (Fig. 2). Hunting pressure is hypothesized to be different between the regions, with higher hunting rates in the Piedmont due to an increased amount of farmland ideal for hunting (L. Williams, pers. comm.).

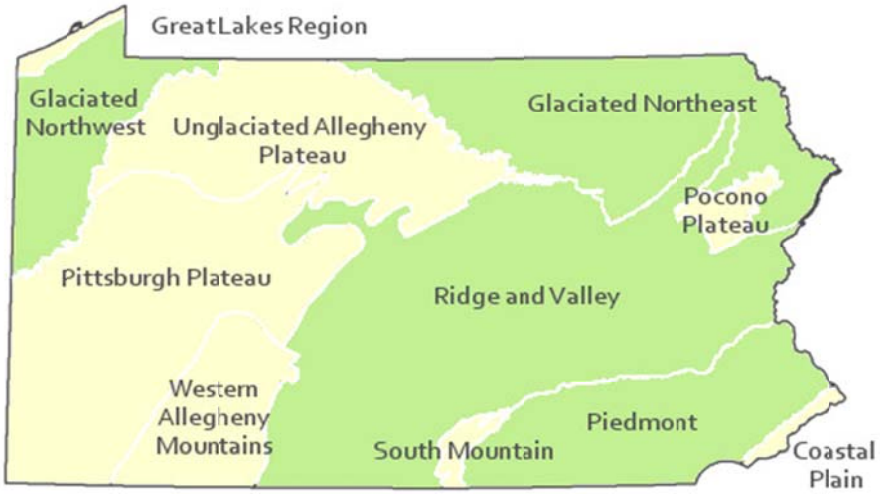

Figure 2: Map of Pennsylvania regions. The Piedmont region is labeled, with all other regions being summarized as non-Piedmont for purposes of the analysis (Zimmerman, 2011)

METHODS

We utilized data collected by L. Williams (Pennsylvania Game Commission) to assess survival and reporting rates of mourning doves from 2003-2013. Doves were banded each year before the hunting season and during the hunting season hunters reported harvested or dead birds. Some birds banded in 2004 received reward bands, but this information was not provided. Bands are routinely applied to doves in the summer between July and August. Hunting season for mourning doves typically lasts from September to January (Seamans and Sanders, 2014).

We used ArcMap 10.2.2 (ESRI 2014) to plot provided coordinate data of banding and recovery regions of all individuals, separating mourning doves into Piedmont and Non-Piedmont regions (Fig. 3). This allowed us to test regional differences in survival.

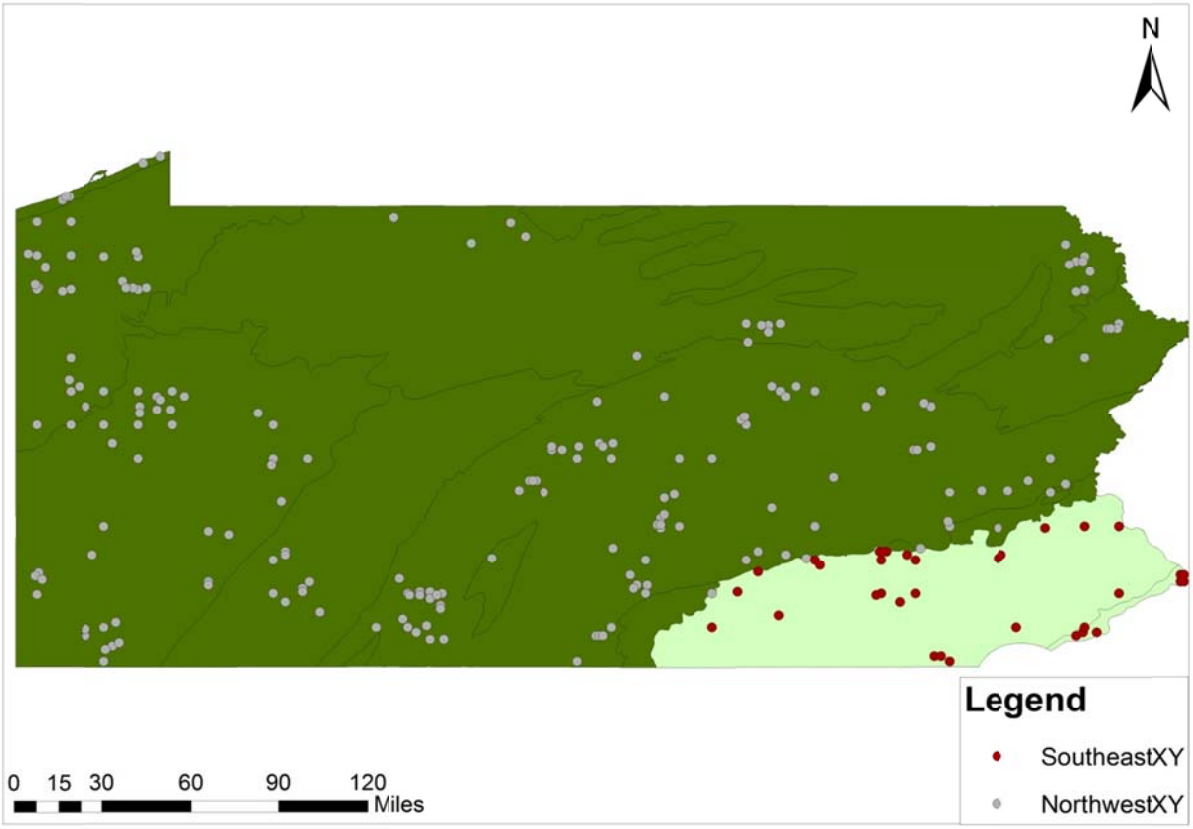

Figure 3: Map of Pennsylvania depicting all banding locations between 2003 and 2013

We used Program MARK (White & Burnham, 1999) to estimate survival and reporting rates by region, year, sex, or a combination of parameters (Table 1). We analyzed the data using a Seber Dead Recovery model (Seber, 1970), allowing for estimation of survival (*S*) and reporting rates (*r*) based on number of doves banded and dead doves recovered (*f*) for each time interval. Recovery rates are dependent on the individual doves being killed and being reported (i.e. (1-*S*)**r*), but due to a lack of reward band information across each year of the project, *f* cannot be estimated.

Due to limited data, only parameters with sufficient data available were considered. While banding locations occurred throughout several ecoregions within Pennsylvania, we grouped

banding locations into the Northwest and Southeast regions based on hypotheses regarding hunting pressure. Due to limited numbers of reported doves in all categories, only AHY animals were used for our initial analysis. Only doves with known sex were included in the analysis.

Table 1: Description of original models run using Program Mark

Model*	Description
S(s)r(t)	Survival varies by sex, reporting varies by time (years)
S(.)r(t)	Survival is constant, reporting varies by time (years)
S(.)r(reg)	Survival is constant, reporting varies by region
S(t+reg)r(.)	Survival varies by time and region, reporting is constant
S(t)r(.)	Survival varies by time, reporting is constant
S(t*reg)r(.)	Survival varies by time by region, reporting is constant
S(s)r(.)	Survival varies by sex, reporting is constant
S(.)r(s)	Survival is constant, reporting varies by sex
S(reg)r(.)	Survival varies by region, reporting is constant
S(t)=r(t)	Survival varies by time, reporting varies by time
S(t*reg)=r(t*reg)	Survival varies by time by region, reporting varies by time by region
S(reg)=r(reg)	Survival varies by region, reporting varies by region

We observed no support for a difference in survival by sex and were able to further investigate the potential differences by age groups by including unknown sex animals in our dataset. A secondary set of models was run focusing on differences in age, region, and time (Table 2).

We ran bootstrap goodness of fit (GOF) tests using the most parameterized models in both the original and secondary sets of models. We were unable to run a GOF test on a more global model with all parameters varying due to a lack of convergence of such a model. Model selection was performed using QAICc as an adjustment for small sample size and a lack of model fit (Burnham and Anderson, 2002).

Table 2: Description of secondary models run after adding in unknown individuals

Model	Description
{S(age) r(t)}	Survival varies by age, reporting varies by time (years)
{S(t*reg) r(.)}	Survival varies by time (years) by region, reporting is constant
{S(age) r(.)}	Survival varies by age, reporting is constant
{S(t+reg) r(.)}	Survival varies by time (years) and region, reporting is constant
{S(t) r(.)}	Survival varies by time (years), reporting is constant
{S(.) r(age)}	Survival is constant, reporting varies by age
{S(.) r(t)}	Survival is constant, reporting varies by time (years)
{S(reg) r(.)}	Survival varies by region, reporting is constant
{S(.) r(reg)}	Survival is constant, reporting varies by region
{S(age) r(reg)}	Survival varies by age, reporting varies by region
{S(t) = r(t)}	Survival varies by time (years), reporting varies by time (years)
{S(t*reg) = r(t*reg)}	Survival varies by time (years) by region, reporting varies by time (years) by region
{S(.) r(age)}	Survival is constant, reporting varies by age
{S(reg) = r(reg)}	Survival varies by region, reporting varies by region
{S(t*age) r(t*age)}	Survival varies by time (years) by age, reporting varies by time (years) by age

We also investigated other model structures on reporting rate for both original and secondary sets of models based on visualizations of reporting rates over the years (See Results, Fig. 6 for more detail). This model had survival varying by age and reporting rates for the years 2003, 2010-2013 held equal and reporting rates for 2004 – 2009 held equal (S(age) r(1=8,9,10,11, 2-7)).

RESULTS

The total number of mourning doves banded from 2003-2013 was 15,570 (Fig. 4). Of the banded birds, 2,437 were banded in the Piedmont. Only 87 of the 532 reported birds were reported in the Piedmont.

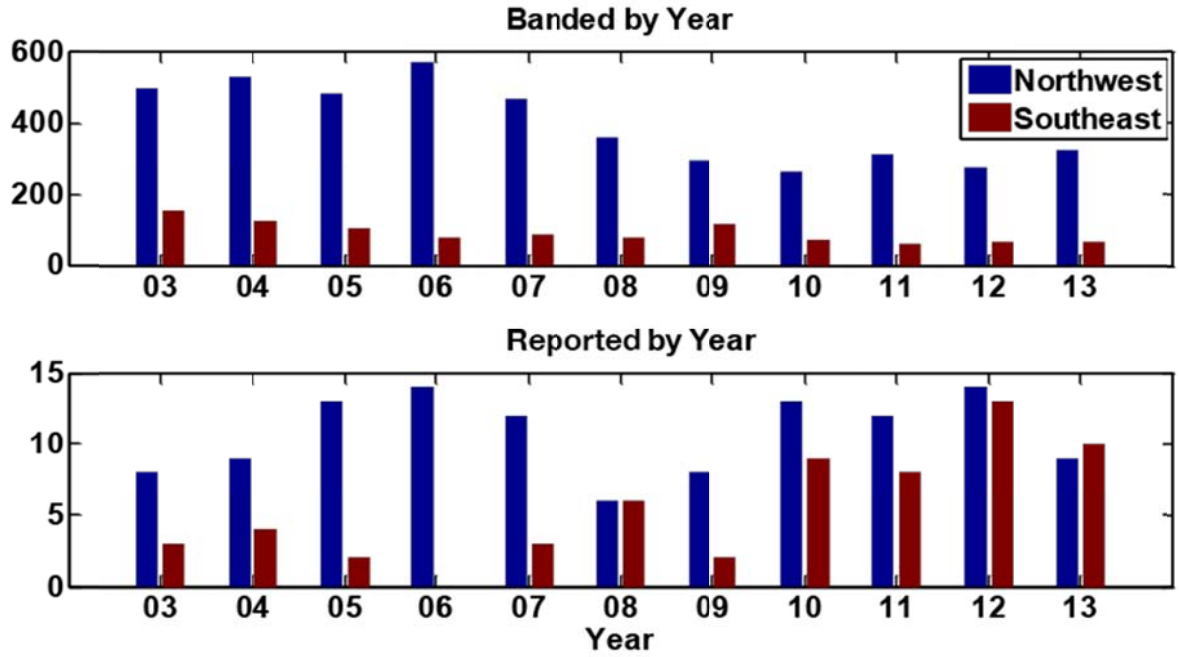

Figure 4: Total animals banded per year by region (top) and reported per year by region (bottom)

Excluding animals with unknown sex, our original analyses were conducted on 5,369 banded animals (3,690 males, 1,003 females), of which only 197 were reported (3.7%; Fig. 5). Our secondary analysis was conducted on 14,703 banded animals, of which only 586 were reported (approximately 4%). Only 83 of the 586 reported birds were from the Piedmont region, although fewer birds were originally banded in the Piedmont (2,215).

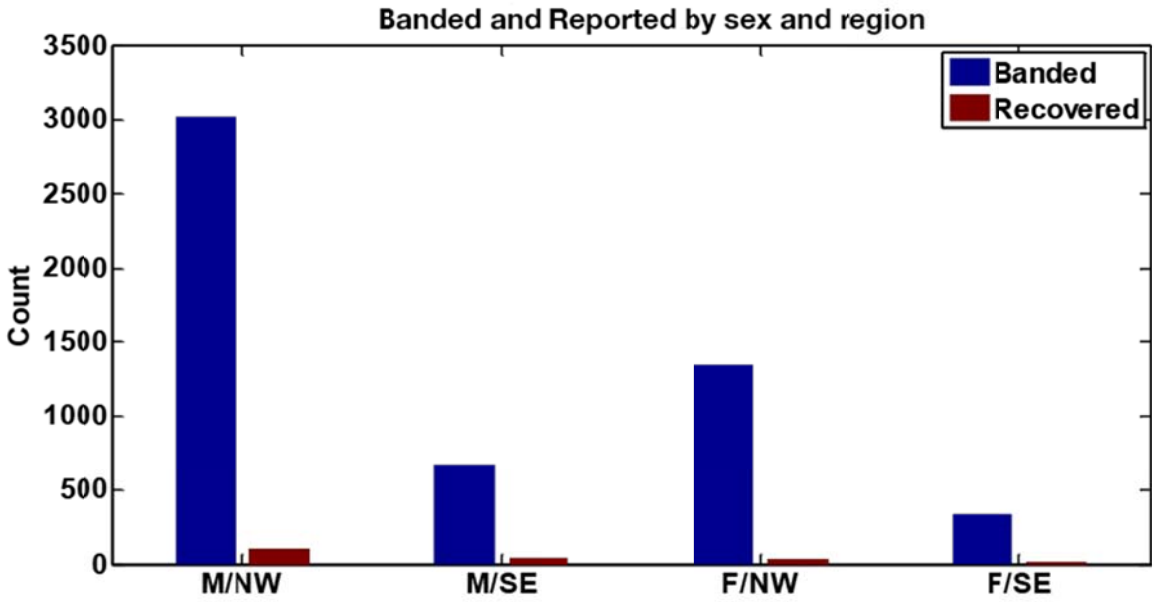

Figure 5: Total numbers of banded and reported male and female birds per region from 2003-2013

To investigate differences in sex, region, and time, we ran models (n = 13) to investigate our hypotheses concerning mourning dove survival (S) and reporting rate (r) (Table 3). The bootstrap GOF test on the most parameterized model (S(t*reg)r(.)) prompted us to adjust the model c-hat by 2.471. Our top ranked model (w = 0.999) allowed for a constant survival rate and reporting rates that vary by regions and by years: reporting rates for the years 2003, 2010-2013 were held equal and reporting rates for 2004 – 2009 were held equal (S(.) r(reg, 1=8,9,10,11, 2-7)). From this model S is estimated as 0.528 (SE ± 0.041, 95% CI = 0.446 – 0.609). Reporting rates were found to be 0.0519 (Piedmont, years 1, 8-11), 0.0243 (Piedmont, years 2-7), 0.118 (non-Piedmont, years 1, 8-11), and 0.030 (non-Piedmont, years 2-7). Standard errors and 95% Confidence Intervals are provided in Table 4.

Table 3: Survival and reporting rate original models for mourning doves banded in Pennsylvania from 2003 – 2013

Model	Δ QAICc	QAICc Weights	Model Likelihood	Num. Par	QDeviance	-2log(L)
S(.)r(reg, 1=8-11, 2-7)	0	0.99922	1	5	108.5854	2145.678
S(.)r(reg)	14.8249	0.0006	0.0006	3	127.417	2192.211
S(.)r(t)	20.0008	0.00005	0.0001	12	114.5392	2160.39
S(s)r(.)	20.2811	0.00004	0	3	132.8733	2205.693
S(.)r(s)	20.6089	0.00003	0	3	133.201	2206.503
S(r)r(.)	20.69	0.00003	0	3	133.2821	2206.703
S(s)r(t)	21.0041	0.00003	0	13	113.5327	2157.903
S(t+reg)r(.)	27.579	0	0	12	122.1174	2179.115
S(t)r(.)	28.4048	0	0	12	122.9432	2181.156
S(t*reg)r(.)	44.1776	0	0	23	116.5676	2165.402
S(t)=r(t)	111.4917	0	0	11	208.039	2391.428
S(t*reg)=r(t*reg)	128.4744	0	0	22	202.8817	2378.684
S(reg)=r(reg)	262.45	0	0	2	377.0443	2809.04

* Variables are time (t), region (reg), sex (s), and constant (.)

Table 4: Reporting rates and confidence intervals for highest ranking model

Region	Years	Reporting Rate (*r*)	Standard Error	95% CI
Piedmont	1, 8-11	0.0519	0.0092	(0.0365, 0.0731)
Piedmont	2-7	0.0242	0.0048	(0.0164, 0.0357)
Other	1, 8-11	0.1182	0.0273	(0.0743, 0.1831)
Other	2-7	0.0302	0.0114	(0.0144, 0.0626)

We chose to set *r* equal for the years 2003, 2010—2013 and 2004—2009 due to strong evidence from a preliminary time-varying model (S (.) r (t)) that recovery rates varied by these year groups (Fig. 6). For this model, *r* ranged from 0.022 to 0.029 for 2004—2009, and from 0.052 to 0.076 for 2003, 2010—2013.

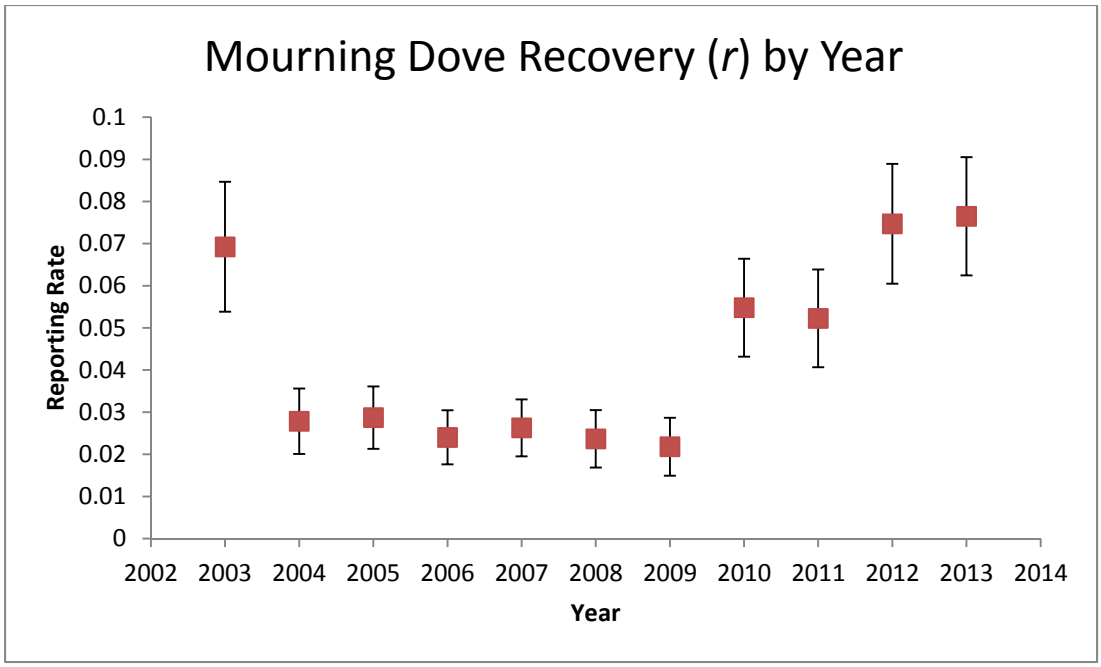

Figure 6: Mourning dove reporting rates by year

We found no support for a difference in survival or reporting rates by sex. We therefore excluded sex in a set of secondary models (n = 15) and were able to include animals with unknown sex to increase sample size and be able to investigate potential effects of age (HY vs. AHY). The bootstrap GOF test on the most parameterized model (S(t*reg)r(.)) prompted us to adjust the model c-hat by 1.804. We found support for two top models (Table 5). The effect of age on survival was supported along with a constant effect on reporting rate (S(age)r(.); w = 0.56) or an effect of time (S(age)r(t); w = 0.33). Due to their high QAICc weights, we model averaged the two.

Our top ranked model (w = 0.951) had survival varying by age and reporting rates for the years 2003, 2010-2013 held equal and reporting rates for 2004 – 2009 held equal (S(age) r(1=8,9,10,11, 2-7)). From this model, HY survival was 0.288 (SE ± 0.032, 95% CI = 0.229 – 0.356) and AHY survival was 0.509 (SE ± 0.030, 95% CI = 0.450– 0.568). Reporting rate for

2003, 2010-2013 was r = 0.052 (SE ± 0.004, 95% CI = 0.045 – 0.061) and for 2004-2009 was r = 0.038 (SE ± 0.003, 95% CI = 0.033 – 0.043).

Table 5: Survival and reporting rate secondary models for mourning doves banded in Pennsylvania from 2003 – 2013

Model	Δ QAICc	QAICc Weights	Model Likelihood	Num. Par	QDeviance	-2log(L)
S(age) r(1=8-11, 2-7)	0	0.9508	1	4	228.1703	6179.02
S(age) r(.)	7.1009	0.0273	0.0287	3	237.2724	6195.44
S(age) r(t)	8.1377	0.01626	0.0171	13	218.2861	6161.189
S(.) r(age)	10.4991	0.00499	0.0052	3	240.6706	6201.571
S(t+reg) r(.)	15.73	0.00037	0.0004	12	227.8819	6178.5
S(t) r(.)	16.3164	0.00027	0.0003	12	228.4683	6179.558
S(t*reg) r(.)	21.7237	0.00002	0	23	211.8216	6149.527
S(reg) r(.)	25.6853	0	0	3	255.8568	6228.966
S(.) r(t)	29.6844	0	0	12	241.8362	6203.673
S(.) r(reg)	33.6792	0	0	3	263.8507	6243.388
S(age) r(reg)}	268.857	0	0	2	501.0293	6671.258
S(t) = r(t)	320.3302	0	0	11	534.4854	6731.612
S(t*reg) = r(t*reg)	431.3722	0	0	22	623.4763	6892.152
S(.) r(age)}	544.3196	0	0	4	772.49	7160.973
S(reg) = r(reg)	618.3441	0	0	2	850.5164	7301.732
S(t*age) r(t*age)}	673.5975	0	0	12	885.7494	7365.293

* Variables are time (t), region (reg), age, and constant (.)

DISCUSSION

As we hypothesized, our best-supported model showed no differences in mourning dove survival or reporting rate by sex. In addition, we found no differences in reporting or survival rates of mourning doves between the Piedmont and the non-Piedmont regions of Pennsylvania. Reporting rate did vary by year, with consistently lower reporting rates from 2004 to 2009 compared to 2003 and 2010 to 2013. Our best-supported model found no differences in dove survival by year.

After finding no differences by sex in survival or reporting rate, we were able to run a second set of models which included birds of unknown sex and age, since any differences could be attributed to age alone. Of the models that included these unknown birds, our best-supported model showed differences in survival by age and differences in reporting rate by year. Therefore, it appears that HY mourning dove survival was lower than AHY survival, and that survival differed by year as in our first set of models.

These findings on mourning doves are similar to those of a study of mourning dove demographic characteristics in western Oklahoma (Lewis and Morrison, 1978). In this study, 410 of the 14,088 doves banded were recovered, mostly from hunter harvest. The top-rated model accounted for a time-varying recovery rate and a constant survival rate (as our best-supported model did) (Lewis and Morrison, 1978). Survival did not vary by sex, and both age classes were grouped due to very little adult recovery data (Lewis and Morrison, 1978).

Additionally, the latest report from the US Fish and Wildlife Service estimated survival and harvest rates for mourning doves in the past 11 years in the eastern United States. These estimates concluded that annual harvest rate was higher for HY individuals compared to AHY individuals (HY rate 42% greater than AHY harvest rate). However, these estimates were obtained by examining a much larger region than the state of Pennsylvania alone (Seamans and Sanders, 2014).

A further study performed synthesized demographic information on a national scale to examine relationships between annual survival and harvest rates of mourning doves. Similar to our analysis, this study utilized program Mark to analyze the predictive ability of various models. The top model of this study showed indicated survival rate varying by age class and by region

and recovery varying by age class and region by time (Otis, 2002). Our top model did not indicate this same variation by region. However, this study was done at a much larger scale than ours and so variation by region is to be expected (Otis, 2002).

Limitations of the Data

Our analyses of the banding data were limited by several aspects of the dataset. For example, sex was unknown for many of the banded birds. In order to analyze the data for differences in survival and reporting rate by this variable, we had to first remove all birds with unknown sex from the analysis. However, after removing these birds, our models did not provide evidence of survival or reporting rate varying by sex. Also, because there were not enough data on HY birds to include age in our analysis, we considered only the AHY birds in our initial models. However, because our models found no differences by sex, we were then able to include the unknown birds in our later models to examine potential differences by age.

In addition, while some birds were banded with reward bands in 2004, the data available for each bird did not include any indication of whether a bird was given a reward band. Therefore, the effect of reward bands could not be modeled even in models accounting for differences by year. However, because the reporting rate for 2004 (r = 0.028) was similar to that for other years (r for 2005 to 2009 ranges from 0.02 to 0.04), it is unlikely that any effect of reward bands in that year is responsible for our models showing reporting rate varying across the eleven years (see Fig. 5).

Although the primary objective of the analysis was to determine whether survival and recovery rates differed by the two regions, the numbers of banded and recovered birds for the Piedmont region were much smaller than those for the non-Piedmont region (Fig. 4 and 5). This may have restricted our ability to detect a difference between the regions due to low sample size.

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