The Effects of Changes in Elk Archery Regulations on Elk Hunter Effort and Harvest, 2004-2010

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By

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ABSTRACT

We evaluated the effects of restrictive changes made to elk archery hunting seasons in eastern Montana on hunter numbers, days, and densities and elk harvest. We compared 2 time periods (2004-2007 and 2008-2010) and grouped hunting districts (HDs) into 1 of 4 HD types. The 4 HD types were limited permits in the Missouri Breaks (7 HDs), limited permits in non-breaks HDs (22 HDs), general season in adjacent HDs which were in close proximity to the limited permit HDs that we hypothesized might receive additional hunters displaced from the two more restrictive archery permit areas (22 HDs) and our pseudo-control HD type which included the rest of the HDs in the state (110 HDs). We expected direct effects on response variables in the two limited permit HD types, indirect effects in the adjacent HDs, and no effects in the pseudo-control HDs as a result of the regulation change in 2008. Using this format, the data were analyzed under a modified before-after control-impact (BACI) design. It appeared that changing the archery regulations to limited permits in 27 HDs did not cause a statistically significant hunter shift to 22 HDs identified as areas hunters would likely select if restrictions forced them to choose a new area. The only significant changes in hunter numbers and days were decreases in non-resident hunter numbers and days in the Missouri River Breaks HDs. Although the decrease in non-resident use may have had an economic impact in the local area; statewide, there was no change in non-resident use. Pseudo-control HDs showed decreases or no change in harvest response variables. Therefore, the significant harvest increases and/or lack of significant harvest declines in the limited permit areas might be interpreted as a relative success. A relative success, because most limited permit areas are above objective and increasing harvests moves us towards the goal of reducing elk numbers in limited permit areas.

INTRODUCTION

Prior to 2008, 22 hunting districts (HDs) in Montana had limited either-sex rifle permits while the archery season was open for either-sex hunting to anyone possessing a general elk license. For the 2008 season these 22 HDs were bundled into eight groupings and hunters were required to draw an archery permit, unlimited in number, for one of the bundled group of HDs. In 2009 and 2010 the number of archery permits issued was limited, and the number issued was based on the number of applicants the previous year. Other season elements remained unchanged, and in most HDs hunters were allowed to hunt antlerless elk without a permit during the archery season. In 2008, regulations in Missouri Breaks HDs also changed from an unlimited number of archery permits to limited permits for the archery season. To date, effects of the regulation changes to overall hunter effort and harvest has not been programmatically evaluated on a statewide basis. Many biologists have questioned whether or not one consequence of the regulation change was an increase in archery hunter numbers in HDs adjacent to the limited permit areas. We therefore analyzed and compared elk hunter and harvest information for the periods 2004-2007 and 2008-2010 across Montana. We had two primary objectives for this analysis; 1) to determine if there was a difference in hunter numbers, hunter days, hunter density, total harvest, antlered harvest, antlerless harvest and harvest with a bow, pre- and post-regulation change in the 4 HD types and 2) to determine whether or not hunters may have shifted to adjacent HDs with less restrictive archery regulations following the archery regulation changes of 2008.

METHODS

For this comparison we placed HDs in one of four HD types (Fig. 1).

1) Breaks Limited Permits (BLPHDs) were 7 HDs in the Missouri Breaks where hunters were required to possess a limited archery permit to hunt elk during the archery season following the 2007 season.

2) Non-Breaks Limited Permits (NBLPHDs) were 22 HDs outside the Missouri Breaks where hunters were required to possess an archery permit to hunt elk during the archery season following the 2007 season.
3) Adjacent HDs (AHDs) were 22 HDs in close proximity to the limited permit HDs that we hypothesized might receive additional hunters displaced from the more restrictive archery permit areas.
4) Other HDs (OHDs) were all other HDs in the state.

We hypothesized that the AHDs selected, might receive additional hunting pressure following the regulation change based on three attributes: 1) proximity to the BLPHDs and NBLPHDs that changed to limited elk archery permits; 2) HDs that had at least a portion of the archery season open to general hunting of elk on a general license; and 3) the professional judgment of biologists responsible for game management in the AHDs. Even if a HD had one or more of the above characteristics we excluded it from the AHDs if the statement "Elk numbers are low and will be difficult to find" appeared in the regulations. We also removed two of the 22 NBLPDs, 520 and 580, from analysis, since both HDs had general hunting in >50% of the HD and after consultation with the local management biologists responsible for those HDs.

Since there were 2 time periods (2004-2007 and 2008-2010) and 4 HD types (BLPHDs, NBLPHDs, AHDs, and OHDs), we were able to analyze the data under a modified before-after control-impact (BACI) design. OHDs represented areas of pseudo-control (no or moderate change in hunting regulations) and the other 3 HD types represented different areas of impact (either directly through regulation change or indirectly through potential hunter shift).

We tested for differences in mean values among responses with HD-year as the sampling units. We tested for changes before-after in the OHDs (control), and in BLPHDs, NBLPHDs, AHDs (impact) relative to observed changes in OHDs. Responses included: 1) hunter days (total, resident and non-resident); 2) hunter numbers (total, resident, and non-resident); 3) hunter density (hunters/square mile of HD); and 4) harvest (total, resident, non-resident, antlered, antlerless and taken with a bow). Harvest survey data doesn't differentiate between hunter numbers or days generated by rifle hunters or archery hunters. Therefore we have an unaccounted source of variation, since changes in rifle regulations could also affect measured parameters in the same or opposite direction as the changes in archery regulations. In addition, permit/license antlerless quota levels in many of the HDs varied between the two time-periods which would especially affect antlerless harvest levels pre and post regulation change. We transformed the response variables using a square-root transformation [square root(x+0.5)], in order to make the data more closely fit a normal distribution. We performed statistical hypothesis tests for differences using a generalized linear model fit to the transformed data. Related to our objectives for this analysis, we tested the following a *priori* hypotheses.

1) Relative to changes in OHDs, mean total, resident and non-resident hunter days were not different pre- and post-regulation change for AHDs, NBLPHDs and BLPHDs.
    a. Hunter displacement alternative: Relative to changes in OHDs, mean total, resident and/or non-resident hunter days increased in AHDs following the regulation changes.
    b. Economic impacts alternative: Relative to changes in OHDs, mean total, resident and/or non-resident hunter days decreased in BLPHDs and NBLPHDs following the regulation changes.
2) Relative to changes in OHDs, mean numbers of total, resident and non-resident hunters were not different pre- and post-regulation change for AHDs, NBLPHDs and BLPHDs.
    a. Hunter displacement alternative: Relative to changes in OHDs, mean total, resident and/or non-resident hunters increased in AHDs following the regulation changes.

   b. Economic impacts alternative: Relative to changes in OHDs, mean total, resident and/or non-resident hunters decreased in BLPHDs and NBLPHDs following the regulation changes.
3) Relative to changes in OHDs, mean density of hunters, was not different pre- and post-regulation change for AHDs, NBLPHDs and BLPHDs.
   a. Hunter displacement alternative: Relative to changes in the OHDs, mean hunter density increased in AHDs following the regulation changes.
   b. Crowding reduction alternative: Relative to changes in OHDs, mean hunter density decreased in BLPHDs and NBLPHDs following the regulation changes.
4) Relative to changes in OHDs, mean total, antlered, and antlerless harvest, was not different pre- and post-regulation change for AHDs, NBLPHDs and BLPHDs.
   a. Hunter displacement alternative 1: Relative to changes in OHDs, mean total, antlered and/or antlerless harvest increased in AHDs following the regulation changes.
   b. Hunter displacement alternative 2: Relative to changes in OHDs, mean total, antlered, and/or antlerless harvest decreased in the BLPHDs and NBLPHDs, following the regulation changes.
   c. Population management alternative: Relative to changes in OHDs, mean total, antlered and/or antlerless harvest increased in BLPHDs and NBLPHDs following the regulation changes.
5) Relative to changes in OHDs, mean number of elk harvested by residents and non-residents was not different pre- and post-regulation change for AHDs, NBLPHDs and BLPHDs.
   a. Opportunity reduction alternative: Relative to changes in OHDs, mean number of elk harvested by residents and/or non-residents in BLPHDs and NBLPHDs decreased following the regulation changes.
   b. Archery hunter displacement alternative: Relative to changes in the OHDs, the mean number of elk harvested by residents and/or non-residents in AHDs increased following the regulation changes.
6) Relative to changes in OHDs, mean number of elk harvested with a bow, was not different pre- and post-regulation change for AHDs, NBLPHDs and BLPHDs.
   a. Opportunity reduction alternative: Relative to changes in OHDs, mean number of elk harvested with a bow, decreased in NBLPHDs and BLPHDs, following the regulation changes.
   b. Archery hunter displacement alternative: Relative to changes in OHDs, mean number of elk harvested with a bow increased in AHDS, flowing the regulation changes.

RESULTS

Differences in mean annual sums of hunting and harvest statistics for the HD types between the two time periods (2004-2007 and 2008-2010) were variable (Tables 1 & 2). Graphed means are means of the response variable by HD-year. The p-values represent significance tests for comparisons between means of each transformed response variable (HD-year as the sampling unit) during the two periods relative to observed changes in the OHDs “control” areas. Tests were considered significant at $p \leq 0.05$ or $p \leq 0.10$.

Hunter Days

The number of total hunter days pre- and post-regulation change were not significantly different in any of the HD types, however, the graphs and comparisons of means suggested that there was an increasing trend in total hunter days following the regulation change in all 4 HD types (OHDs, AHDs, BLPHDs and

NBLPHDs) (Table 1 & Fig. 2). There was a significant increase in resident hunter days generated in the OHDs ($p \leq 0.10$) (Table 1). Although the number of resident hunter days pre- and post- regulation change were not significantly different in the other 3 HD types (AHDs, BLPHDs and NBLPHDs) the graphs and comparisons of means suggested that there was an increasing trend in each HD type (Fig. 3). There was a significant decrease in the number of non-resident hunter days generated in the BLPHDs ($p \leq 0.05$). The number of non-resident hunter days generated post-regulation change showed an insignificant increase in the OHDs and NBLPHDs. There was an insignificant decrease in the AHDs, even though there was a large spike in non-resident hunter days in 2010 (Table 1 & Fig. 4).

Hunter Numbers & Density

Although the number of total hunters and resident hunters pre- and post-regulation change were not significantly different in any of the 4 HD types the graphs and comparisons of means suggested that there was an increasing trend in total hunters and resident hunters, following the regulation change in all 4 HD types (OHDs, AHDs, BLPHDs and NBLPHDs) (Figs. 5 & 6). There was a significant decrease in the number of non-resident hunters in the BLPHDs ($p \leq 0.10$) (Table 1). In addition, the number of non-resident hunters, post-regulation change, decreased insignificantly in the OHDs and AHDs (Table 1 & Fig. 7). In the NBLPHDs, there was an insignificant increase in the number of non-resident hunters (Table 1 & Fig. 7). None of the HD types showed a significant increase in density of hunters post-regulation change (Table 1). However, between the two time-periods all 4 HD types displayed an insignificant, increasing trend towards higher hunter densities.

Harvest

Total harvest in the OHDs showed significant declines ($p \leq 0.10$) post-regulation change while there was an insignificant decline in BLPHDs and insignificant increases in total harvest in AHDs and NBLPHDs (Table 2 & Fig. 8) There was a significant decrease in antlered harvest ($p \leq 0.05$) in the OHDs and a significant increase ($p \leq 0.10$) in antlered harvest in the NBLPHDs. There were no significant changes in antlered harvests in the BLPHDs and AHDS (Table 2 & Fig. 9). There was a significant increase in antlerless harvest in the AHDs along with no significant changes in antlerless harvests in the OHDs, BLPHDs, or NBLPHDs (Table 2 and Fig. 10).

There was a significant decrease in resident harvest ($p \leq 0.10$) and no significant changes in non-resident harvest in the OHDs. There were no other significant post-regulation changes in the total numbers of elk harvested by resident or non-resident hunters (Table 2 and Figs. 11-12). Only the NBLPHDs ($p \leq 0.10$) showed a significant increase in the numbers of elk taken with a bow (Table 2).

Discussion

The FWP Commission implemented restricted-entry archery elk hunting regulations in the Missouri River Breaks and 22 other HDs with limited-entry rifle elk hunting regulations beginning in 2008. The objectives of the regulation changes were equitable allocation of elk hunting opportunity among user groups, consistent application of regulations across HDs, minimization of crowding, minimization of hunter displacement to other districts, and maximization of the ability to manage elk herds within specified objectives using antlerless elk harvest during the general season.

This analysis addressed whether or not hunters shifted to adjacent HDs, and whether or not response variables increased, decreased or remained static in 4 HD types following the regulation changes. To a lesser degree, these analyses can comment on the ability of these regulation types to manage elk herds

within specified population objectives. In the hunter harvest surveys we can't differentiate between archery and rifle hunter numbers and hunter days so changes observed in those response variables were not necessarily a direct result of the regulation change. However, we can comment on whether or not the regulation changes moved us closer to the stated objectives for the Elk Management Units affected by those changes.

It appeared that changing the regulations to a more restrictive archery season type in the 7 breaks HDs and 22 non-breaks HDs didn't cause significant increases in hunter numbers, total hunter days, hunter densities or total harvest in AHDs that biologists hypothesized might be most impacted if hunters were displaced from the limited permit HDs. The only significant increase observed in AHDs was antlerless harvest. Since a majority of the elk killed with a bow were antlered, the increase in AHD's antlerless harvests was probably influenced more by antlerless season structure in those HDs, than archery season structure in the BLPHDs and NBLPHDs. We originally hypothesized that, because of the additional restrictions in NBLPHDs, hunters would shift away from those HDs, however, this hypothesis was not supported. Instead the graphs and comparisons of means suggested increasing trends in hunter and harvest response variables in NBLPHDs. The only significant changes in hunter numbers and days observed were decreases in non-resident hunter numbers and days in the BLPHDs. Although the decrease in non-resident use may have had an economic impact in the local area; statewide, there was no statistical change in non-resident hunter numbers and days It is possible that we did not detect significant differences in many of the response variables because our harvest survey estimates are not accurate and precise enough to detect the changes, that within the same HD types, some individual HDs had significant increases while other HDs had decreases, or that other regulation changes in the same time periods masked the magnitude of changes between the two time-periods. We also note that elk archery regulation changes are only one aspect of the hunting regulations that affect elk hunting effort and harvest, and that most elk license holders do not hunt with archery equipment or harvest elk with a bow. Therefore, it is possible that the lack of effects we observed was real, because other aspects of elk regulations were more consistent drivers of hunter numbers and harvest. Even though we were unable to detect a statistical difference in hunter numbers and days in the AHDs, the observations by management biologists that "hunter numbers during the archery season are increasing rapidly in the AHDs" is almost certainly accurate. However, if the increase in the AHDs were a result of this archery regulation change, we should have expected a decline in hunter numbers and days in the NBLPHDs and BLPHDs rather than the statistically insignificant increases we observed. It is possible that the hunter number increases observed by biologists in the AHDS may be the result of a combination of factors including the increasing popularity of archery hunting, a shift from the OHDs and/or a shift of archery hunters away from HDs with grizzly bears and wolves.

Twenty-one of twenty-four HDs in the NBLPHDs and BLPHDs are over objective (Table 3). To achieve population objectives, we will have to increase adult female harvest and in some cases adult female and male harvests. There were significant decreases in total and antlered harvests in the OHDs even though hunter effort was stable (or slightly increasing for resident hunter days). Relative to these trends in our OHD pseudo-control districts, the significant increases and/or lack of significant declines in harvest statistics in the BLPHDs and NBLPHDs might be interpreted as a relative success since increasing harvests moves us closer toward the stated goal of managing elk herds within specified objectives. This interpretation would be faulty if the root cause of the decline in harvest statistics in OHDs was not present or differed from the drivers of elk harvest in the other HD types. In other words, we are assuming that the OHDs can serve as a pseudo-control in this analysis, for comparison to the effects of implementation of the new archery regulations. Our analyses and results could be suspect if this assumption is not valid. This is somewhat concerning since implementation of the new regulations occurred primarily in eastern Montana, while the OHDs are primarily in western Montana (Fig. 1). The primary drivers of elk harvest

may differ between eastern and western Montana (e.g., the effect of snow, or the presence of multiple large carnivores), regulations other than archery regulation changes and elk population sizes may also affect elk harvest. Quantification of the drivers of elk harvest across Montana would help us to interpret these results more thoroughly.

Graphs and means suggested that hunter numbers remained stable or increased in OHDs while total and antlered harvests showed significant decreases. If the trend towards decreasing harvests in the OHDs continues we could see hunters shift from the OHDs to one or more of the other HD types.

Interpretation of the graphs and means suggested that non-resident hunter numbers showed an increasing trend in the NBLPHDs while the other HD types showed insignificant decreases. Although both the increase and decreases were insignificant, at the precision that harvest surveys can provide, we believe the trend towards higher use by non-residents and its effect on the equitable allocation of elk hunting opportunity among user groups should be monitored closely in the future.

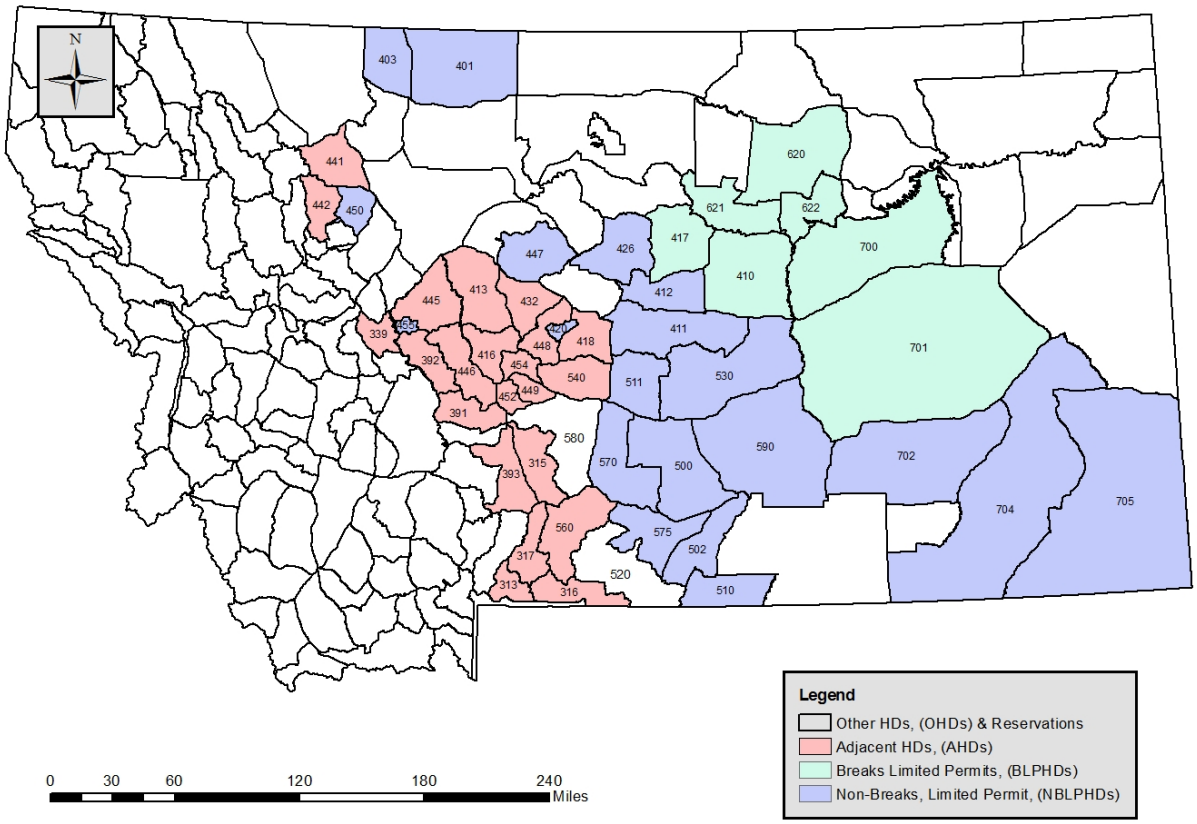

Figure 1. Hunting districts in the state of Montana that were, and may have been affected by changes to the elk archery season structure in 2008. Note 520 and 580 excluded from analysis.

Table 1. Results of statistical tests on hunter response variables. An upper case X indicates significance at p≤0.05, a lower case x indicates significance at p≤0.10.

All Other Hunting Districts (OHDs)							
	Mean						
Response Variable	2004-07	2008-10	DIFF.	P-Value[1]	Increase	Decrease	No Change
Hunter Days							
Total	642,877	697,137	54,260	0.150			X
Residents	565,046	617,593	52,547	0.097	x		
Non-Residents	77,831	79,545	1,714	0.369			X
Hunters							
Total	99,058	99,496	438	0.743			X
Residents	86,620	87,657	1,037	0.589			X
Non-Residents	12,437	11,839	-599	0.967			X
Hunter Density							
Total	2.25	2.27	0.02	0.620			X
Adjacent Hunting Districts (AHDs)							
	Mean						
Response Variable	2004-07	2008-10	DIFF.	P-Value	Increase	Decrease	No Change
Hunter Days							
Total	111,234	130,470	19,236	0.766			X
Residents	92,292	111,770	19,479	0.691			X
Non-Residents	18,943	18,699	-243	0.689			X
Hunters							
Total	20,290	22,060	1,770	0.679			X
Residents	16,956	18,825	1,869	0.626			X
Non-Residents	3,334	3,235	-99	0.988			X
Hunter Density							
Total	2.30	2.44	0.13	0.749			X
Breaks Hunting Districts (BLPHDs)							
	Mean						
Response Variable	2004-07	2008-10	DIFF.	P-Value	Increase	Decrease	No Change
Hunter Days							
Total	38,075	40,433	2,357	0.919			X
Residents	27,835	34,893	7,058	0.545			X
Non-Residents	10,240	5,540	-4,700	0014		X	
Hunters							
Total	6,125	6,282	156	0.762			X
Residents	4,818	5,489	670	0.507			X
Non-Residents	1,307	793	-514	0.082		x	
Hunter Density							
Total	0.69	0.73	0.04	0.982			X
Non-Breaks Permitted Areas, Excluding 580 and 520 (NBLPHDs)							
	Mean						
Response Variable	2004-07	2008-10	DIFF.	P-Value	Increase	Decrease	No Change
Hunter Days							
Total	38,286	52,168	13,882	0.638			X
Residents	33,220	45,138	11,918	0.706			X
Non-Residents	5,066	7,031	1,965	0.542			X
Hunters							
Total	6,488	8,182	1,694	0.439			X
Residents	5,693	7,123	1,430	0.508			X
Non-Residents	795	1,059	264	0.299			X
Hunter Density							
Total	0.50	0.78	0.28	0.483			X

[1]P-values are a test of significance on the means of each response variable by hunting district type for the periods 2004-2007 and 2008-2010. Means in table are the means of the sum of the response variables for the two time periods 2004-2007 and 2008-2010.

Table 2. Results of statistical tests on harvest response variables. An upper case X indicates significance at p≤0.05, a lower case x indicates significance at p≤0.10.

All Other Hunting Districts (OHDs)							
	Mean						
Response Variable	2004-07	2008-10	DIFF.	P-Value[1]	Increase	Decrease	No Change
Harvest							
Total	16,902	14,691	-2,211	0.069		x	
Antlered	8,268	6,976	-1,292	0.041		X	
Antlerless	8,595	7,715	-880	0.124			X
Residents	14,280	12,447	-1,833	0.091		x	
Non-Residents	2,623	2,244	-379	0.122			X
Taken w Bow	1393	1321	-72	0.629			X
Adjacent Hunting Districts (AHDs)							
	Mean						
Response Variable	2004-07	2008-10	DIFF.	P-Value	Increase	Decrease	No Change
Harvest							
Total	4,555	4,940	385	0.203			X
Antlered	2,253	2,194	-58	0.492			
Antlerless	2,292	2,746	454	0.091	x		
Residents	3,586	3,901	315	0.215			X
Non-Residents	970	1,039	70	0.175			X
Taken w Bow	332	361	29	0.257			X
Breaks Hunting Districts (BLPHDs)							
	Mean						
Response Variable	2004-07	2008-10	DIFF.	P-Value	Increase	Decrease	No Change
Harvest							
Total	1,910	1,556	-354	0.954			X
Antlered	745	708	-36	0.704			X
Antlerless	1,159	848	-312	0.711			X
Residents	1,592	1,317	-275	0.958			X
Non-Residents	318	239	-79	0.489			X
Taken w Bow	480	410	-70	0.349			X
Non-Breaks Permitted Areas, Excluding 580 and 520 (NBLPHDs)							
	Mean						
Response Variable	2004-07	2008-10	DIFF.	P-Value	Increase	Decrease	No Change
Harvest							
Total	1,445	1,672	227	0.220			X
Antlered	650	822	172	0.090	x		
Antlerless	791	850	58	0.393			X
Residents	1,255	1,417	162	0.278			X
Non-Residents	190	255	65	0.108			X
Taken w Bow	229	321	92	0.060	x		

[1]P-values are a test of significance on the means of each response variable by hunting district type for the periods 2004-2007 and 2008-2010. Means in table are the means of the sum of the response variables for the two time periods 2004-2007 and 2008-2010.

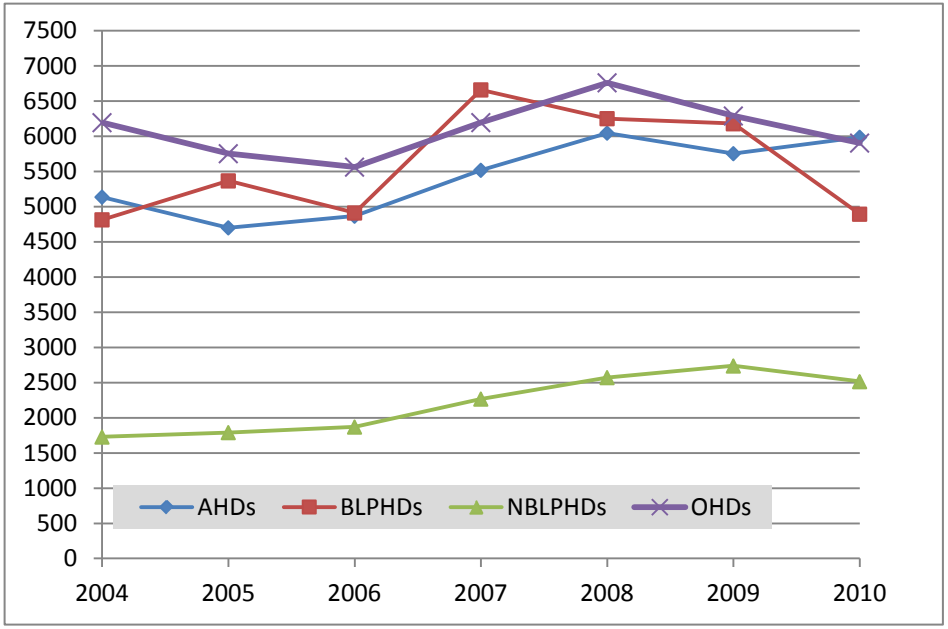

Figure 2. Average total number of hunter days per HD type, 2004-2010.

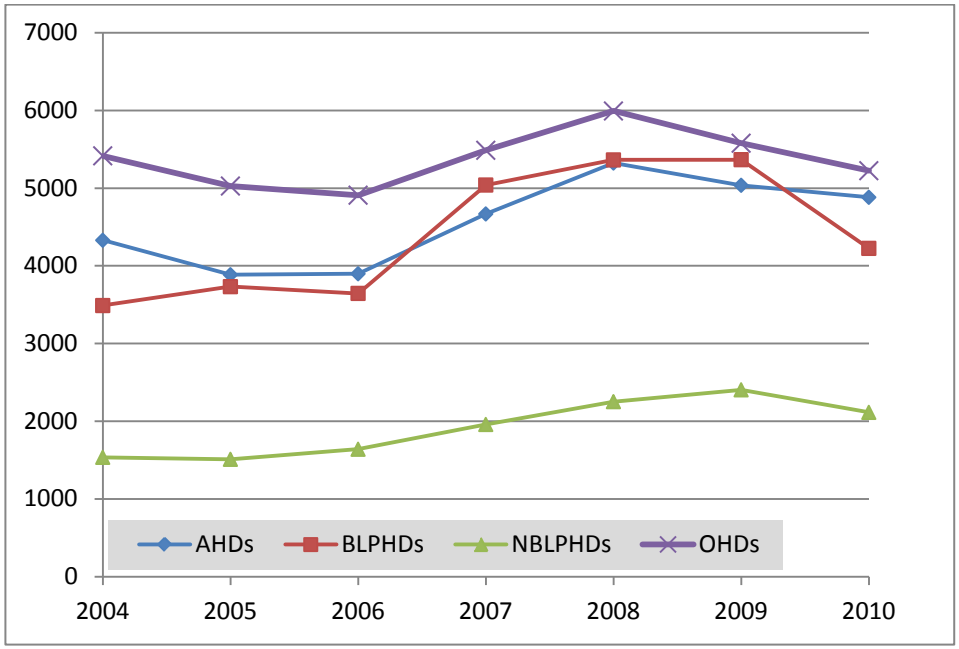

Figure 3. Average total number of resident hunter days per HD type, 2004-2010.

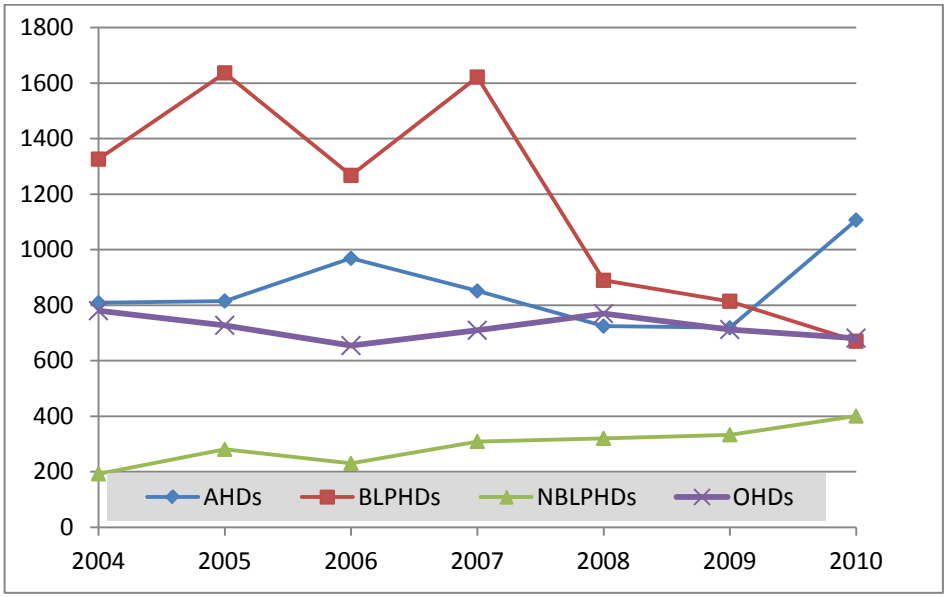

Figure 4. Average total number of non-resident hunter days per HD type, 2004-2010.

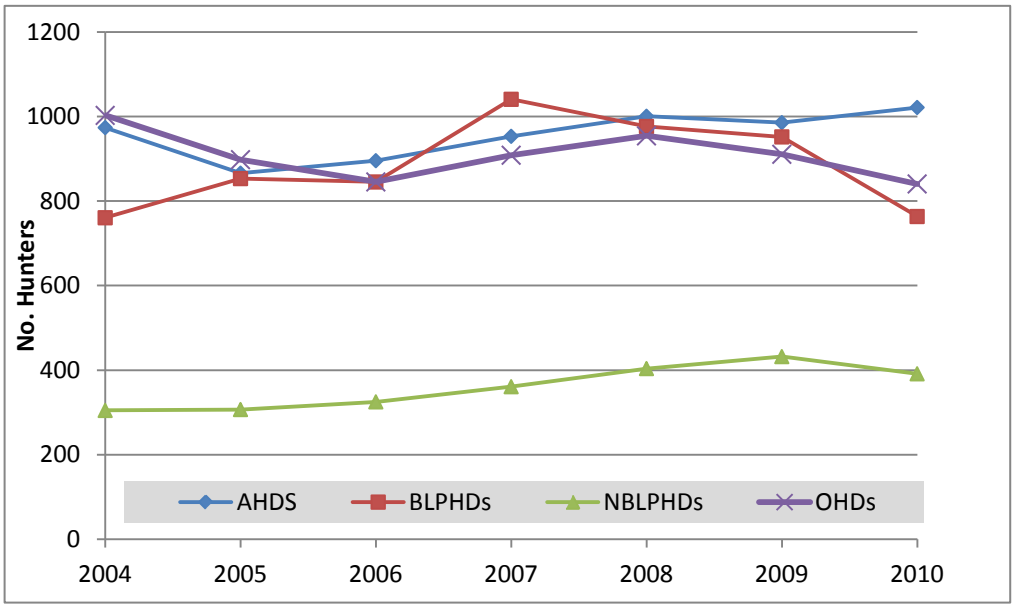

Figure 5. Average number of total hunters per HD type, 2004-2010.

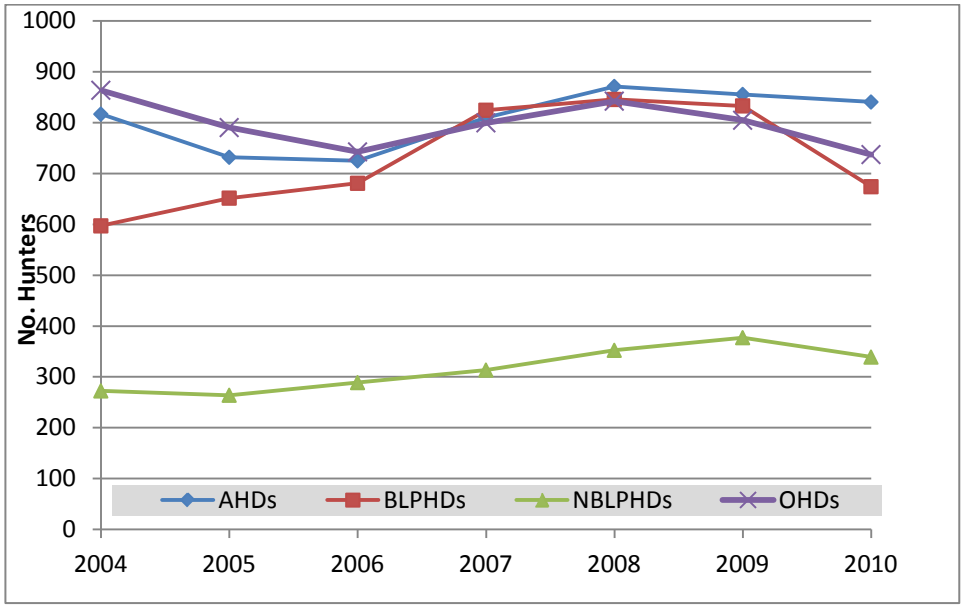

Figure 6. Average number of resident hunters per HD type, 2004-2010.

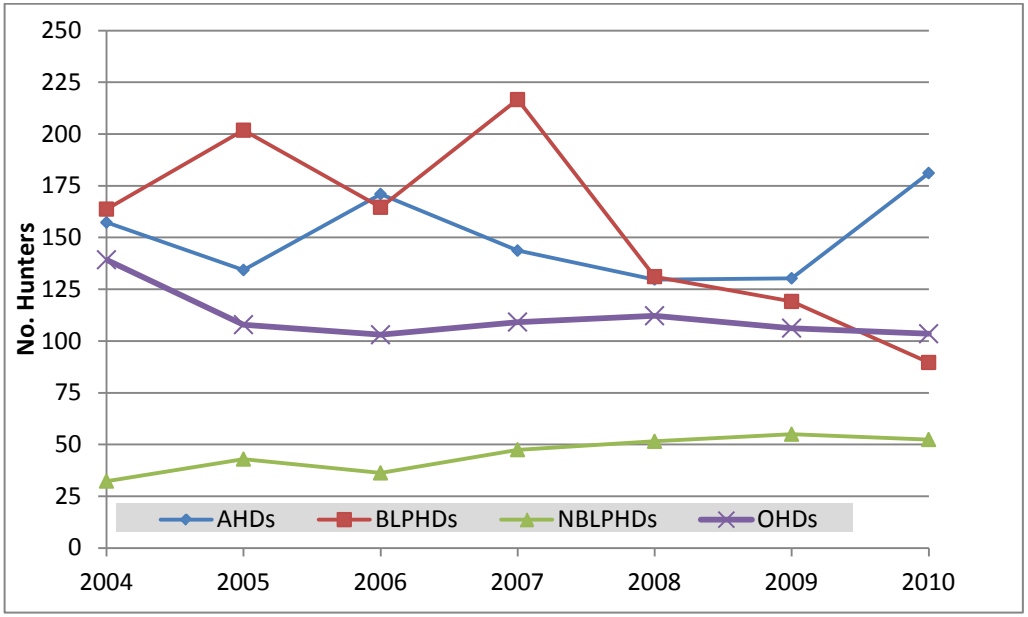

Figure 7. Average number of non-resident hunters per HD type, 2004-2010.

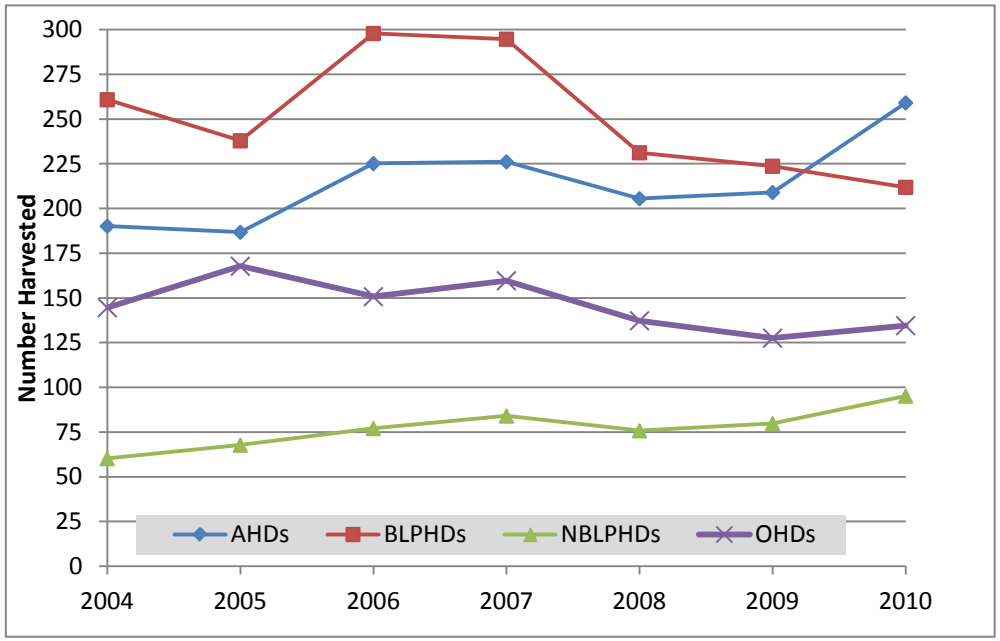

Figure 8. Average total elk harvest per HD type, 2004-2010.

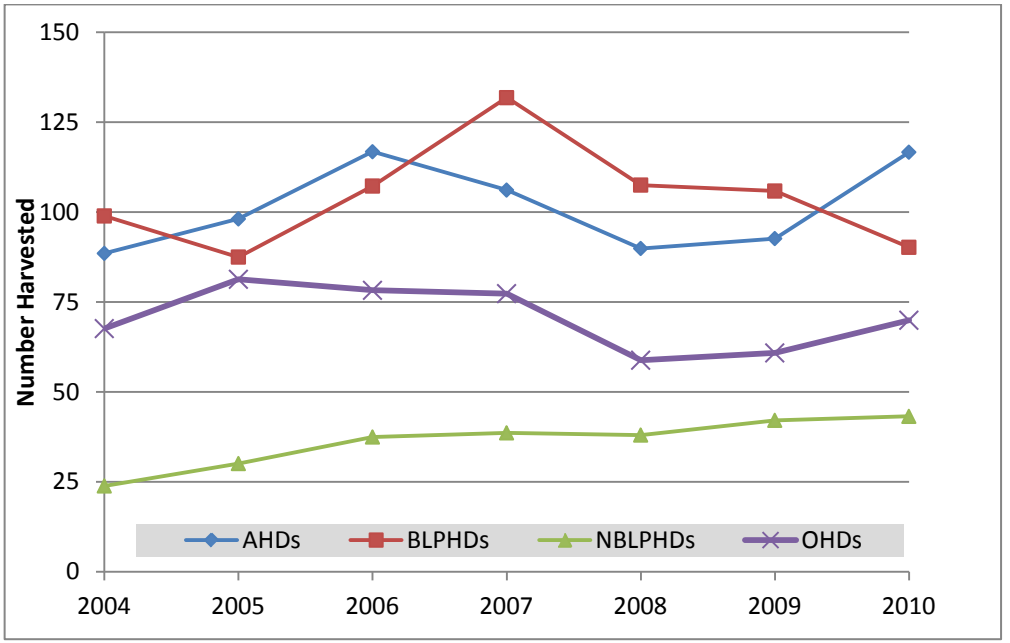

Figure 9. Average antlered harvest per HD type, 2004-2010.

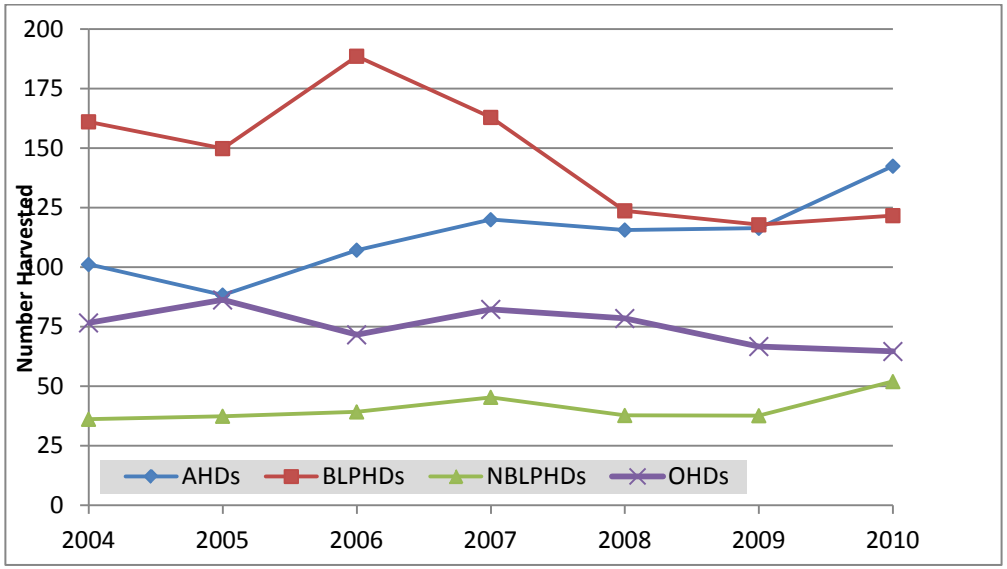

Figure 10. Average antlerless harvest per HD type, 2004-2010.

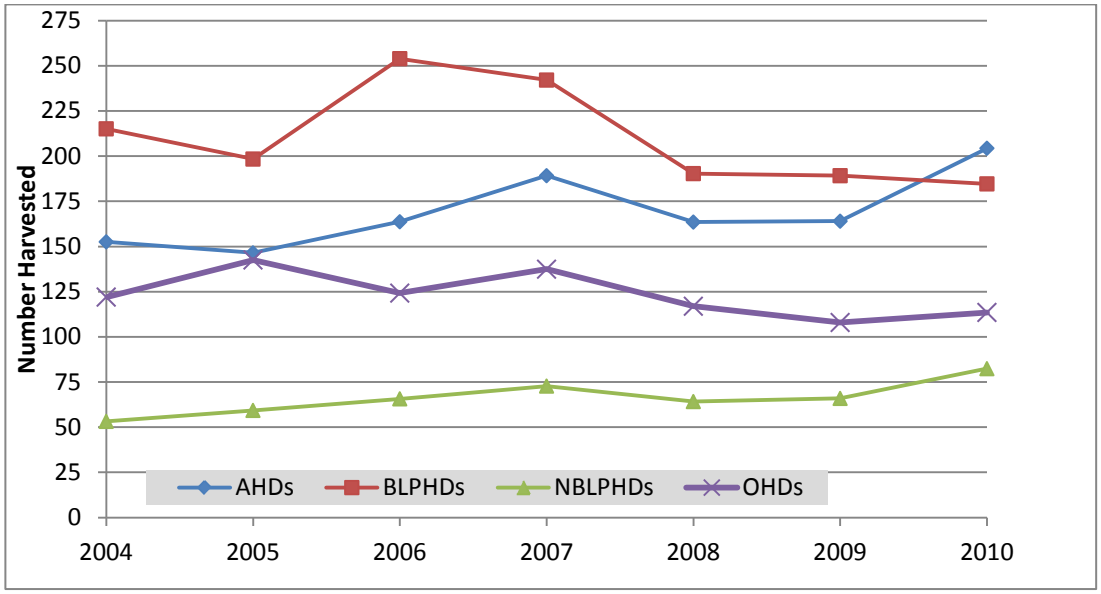

Figure 11. Average numbers of elk harvested by residents per HD type, 2004-2010.

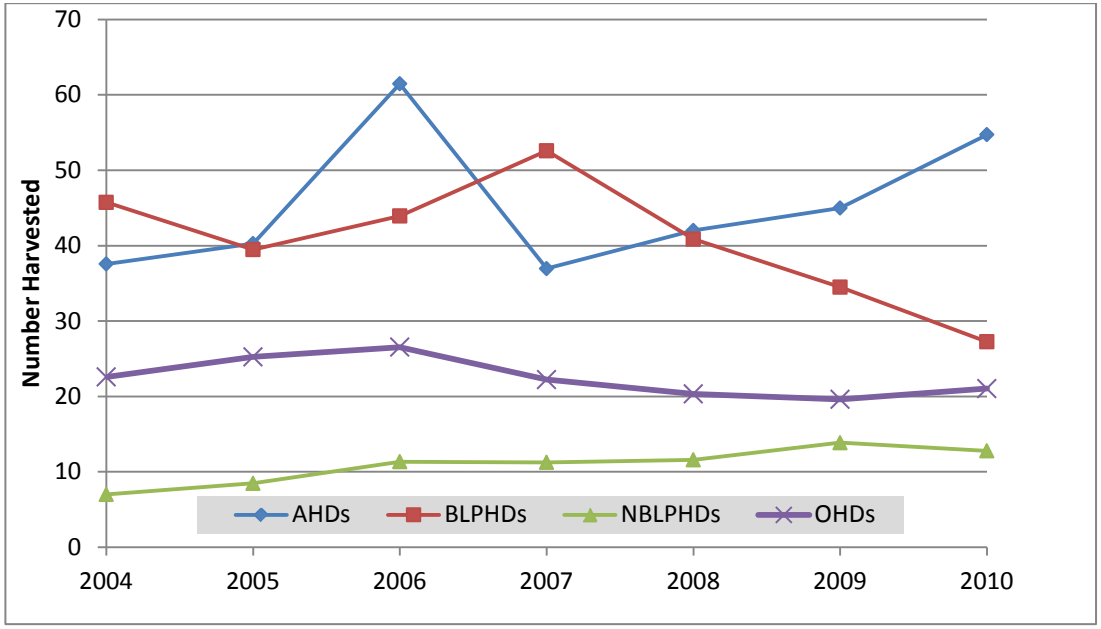

Figure 12. Average numbers of elk harvested by non-residents per HD type, 2004-2010.

Table 3. Population objective status in the breaks and non-breaks limited permit HDs, spring 2011.

Hunting District(s)	HD Type	Population Objective
410	BLPHDs	At Objective
417	BLPHDs	Over Objective
620, 621, 622	BLPHDs	Over Objective
700, 701	BLPHDs	Over Objective
401	NBLPHDs	Over Objective
403	NBLPHDs	Unknown
411, 412, 511, 530	NBLPHDs	Over Objective
420	NBLPHDs	At Objective
426	NBLPHDs	Unknown
447	NBLPHDs	Over Objective
450	NBLPHDs	Over Objective
455	NBLPHDs	Over Objective
500	NBLPHDs	Below Obj.
502	NBLPHDs	Over Objective
510	NBLPHDs	Unknown
570	NBLPHDs	Over Objective
575	NBLPHDs	Over Objective
590	NBLPHDs	Over Objective
702, 704, 705	NBLPHDs	Over Objective