The Effects of Special Mule Deer Buck Regulations on Mule Deer Populations and Harvest

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By

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ABSTRACT

We evaluated the effects of 3 restrictive season types on mule deer population and harvest characteristics in 41 hunting districts (HDs) widely distributed across Montana compared to population and harvest characteristics for the remaining mule deer HDs in Montana. We analyzed 6 harvest and hunter use response variables estimated annually through the telephone harvest survey, as well as 4 population response variables collected during annual aerial surveys. We used a mixed-effects, before-after-control-impact modeling framework, which allowed us to compare changes in the response variables as a function of changes in regulation, while allowing each HD to differ in its overall mean response values. We found clear evidence that season restrictions affected population and harvest parameters. Results indicated that using buck restrictions to achieve specific buck:doe ratio objectives was effective as long as the objectives were not too high. Limited permit HDs had the highest buck:doe ratios, followed by shortened season HDs. Buck:doe ratios observed in unlimited permit HDs were not much different than HDs with no restrictions. We found that buck:doe ratios increased significantly, by .42 bucks:100 does and .33 bucks :100 does per year, following implementation of season restrictions in the shortened season and limited permit HDs, respectively, while there was not a significant change in buck:doe ratios in the unlimited permit HDs. Although the estimated change in the buck:doe ratio in unlimited permit HDs was not significant, it was the only restriction type that showed a weak decreasing trend in buck:doe ratios with time. All restrictive season types resulted in declines in hunters and hunter days. HDs with no restrictions, with limited permits and with unlimited permits further showed a downward annual trend in hunter numbers. The downward trend in hunter numbers was steepest for HDs with unlimited permits followed by HDs with limited permits. In the shortened season HDs, there was a significant one-time loss in hunter numbers, however over time hunters tended to shift back to those HDs. We estimated that it would take approximately 20 years for hunter numbers in shortened season HDs to return to the level observed in HDs with no restrictions. Limited permit HDs had a statistically greater proportion of bucks with ≥4 points on at least one antler, a lower number of bucks harvested annually, and a smaller total number of ≥4 point bucks harvested than in HDs with no buck restrictions. Unlimited and shortened season HDs statistically, were not different than HDs without restrictions, for the proportion of bucks with ≥4 points on at least one antler, for the number of bucks harvested annually, and for total number of ≥4 point bucks harvested. In all three restricted regulation HDs there was an annual increase in the observed spring fawn:adult ratios even though the general trend was for a decreasing fawn:adult ratio of 0.83 fawns:100 adults per year in HDs with no restrictions.

INTRODUCTION

In February of 1998 the Montana Fish, Wildlife and Parks (MFWP) Commission adopted a deer management policy to serve as a basis for establishment of deer hunting regulations. Because of this policy decision, MFWP developed a harvest management strategy that incorporated Adaptive Harvest Management (AHM) concepts into hunting regulations (MFWP 2001). MFWP divided the state into 5 Population Management Units (PMUs), the Northwest Montane, Mountain Foothill, Prairie/ Mountain Foothill, Southern Mountains and Prairie/Breaks Units. Regulations, categorized as liberal, standard and restrictive, were established for each PMU and population and/or harvest objectives provided triggers that resulted in changes to regulations. Through a 1998 deer hunter survey, FWP determined that approximately 23% of deer hunters could be categorized as trophy hunters (MFWP 2001). Because of this documented demand for trophy deer hunting opportunity, MFWP set aside 16 hunting districts (HDs) where buck harvest opportunity was limited in order to decrease the harvest of antlered bucks, increase post season buck:doe ratios, and meet the demand to harvest an older-age-class buck in areas with good access. Objectives were established for each of these Special Management Districts (SMDs), for post-season buck:doe ratios, percentages of older-age-class bucks, and/or specified a percentage of bucks harvested with 4 or more points on either side (Table 1).

In addition, the AHM document identified HDs 400, 401, 403 and 406 as HDs, which would benefit from a shortened 3-week mule deer buck season. We categorized HDs 400, 401, 403, and 406 as Restrictive Season Hunting Districts (RSHDs) and analyzed data from these districts along with data from 21 additional HDs that had restrictions on the harvest of mule deer bucks in the 2011 season (Table 2). HDs 400, 401, 403 and 406 were in the Prairie/ Breaks PMU while all the other RSHDs were located in the Northwest Montane and Mountain Foothill PMUs. Managers established mule deer buck objectives in the Northwest Montane and Mountain Foothills PMUs to maintain at least 10 bucks per 100 does in the observed post-

Table 1. Original SMDs in the state of Montana with special regulations to limit mule deer buck harvest[1].

			Objectives	
HD	Years of Restrictive Regulation	Restrictive Season Type	Post-Season Bucks:100 Does	Harvested Buck
202	1998-present	Limited Buck Permits	40:100	30% ≥4 years old
210	1998-present	Limited Buck Permits	40:100	30% ≥4 years old
261	1998-present	Limited Buck Permits	40:100	30% ≥4 years old
270	1998-present	Limited Buck Permits	40:100	30% ≥4 years old
291	1998-present	Limited Buck Permits	40:100	30% ≥4 years old
300	1998-present	Limited Buck Permits	25:100	30% ≥4 years old
312	1998-present	Limited Buck Permits(portion of HD)	25:100	30% ≥4 years old
313	1994-present	Short Season	15:100	35% ≥ 2.5 years old
320	2001-present	Short Season	25:100	none
324	2000-present	Limited Buck Permits	25:100	40% ≥4 years old
333	2001-present	Short Season	25:100	none
441	1987-present	2 weeks Gen A, last 3 weeks limited permits on private lands 50 Permits	25:100	60% ≥4 points
455	1992-present	Limited Buck Permits valid for mule deer and whitetails.	20:100	50% ≥4 points
510	1998-present	Unlimited Buck Permits	25:100	30% ≥ 4 years old
530	1987-present	Limited Buck Permits	25:100	30% ≥ 4 years old
652	1996-present	Limited Buck Permits	40:100	50% ≥ 4.5 years old & 30% ≥5.5 years old & ≥3.0 mule deer per sq. mi.

[1]Table does not include areas with weapon restrictions.

season population of deer. The RSHDs buck:doe objectives, unlike objectives for SMDs, were not designed to produce larger and more mature bucks.

All PMUs have a series of objectives and triggers, that when reached, suggest to managers when to move from restrictive to standard or to liberal season types. In the Northwest Montane PMU manager's may recommend that harvest of mule deer bucks be restricted by issuing unlimited mule deer buck permits, if the post-season buck:doe ratio is less than 10 bucks:100 does for two consecutive years or if the harvest of bucks with 4 or more points was less than 25% of the total buck harvest. In the Mountain Foothills PMU manager's may recommend that harvest of mule deer be restricted, by issuing unlimited mule deer buck permits, if the post-season buck:doe ratio is less than 10 bucks:100 does following 2 years of fawn recruitment greater than 40 fawns:100 adults.

In previous season setting processes, sportsmen groups have asked MFWP to manage more HDs for trophy hunting opportunities. Since 2011-12 is a season setting year and mule deer numbers are relatively low in many HDs, it is likely that there will be requests to increase the number of HDs that limit harvest of mule deer bucks. In preparation for the 2011-12 season setting process, MFWP compiled and analyzed existing data from the SMDs and RSHDs across the state. This information will provide the basis for discussions with sportsmen as to the merits and drawbacks of hunting seasons that restrict harvest on mule deer bucks. The primary objective of this analysis was to quantify differences between HDs with special mule deer buck regulations and HDs without special mule deer buck regulations. We compared current population and harvest parameters to those same parameters measured prior to the season structure change and to other HDs without restrictions. We treated post season buck:doe ratios, number of bucks with ≥4 points on each side, and hunter participation data as response variables in these analyses. Secondary objectives were to evaluate whether or not limited buck hunting has had any measurable effect on productivity of the population by analyzing differences in spring fawn:adult ratios and spring trends in total numbers. The final objective was to compare established population objectives to observed population parameters.

Table 2. HDs, other than the original SMDs with a restriction on the hunting of mule deer bucks RSHDs[1], 2011.

Hunting District	Years of Restrictive Regulation	Restrictive Season Type	Objectives	
			Post-Season Bucks:100 Does	Harvested Buck
204	1999-present	Unlimited Buck Permits & Short Season	>10:100	None
212	2007-present	Unlimited Buck Permits	>10:100	None
213	2007-present	Unlimited Buck Permits	>10:100	None
214	2007-present	Unlimited Buck Permits	>10:100	None
240	1999-present	Unlimited Buck Permits	>10:100	None
250[2]	1999-2009	Unlimited Buck Permits	>10:100	None
260[3]		No Mule Deer Season	NA	
281	1998-present	Unlimited Buck Permits	>10:100	None
282[3]		Restrictions Apply	>10:100	None
292	2000-present	Unlimited Buck Permits Valid in 298	>10:100	None
298[4]	2008-present[5]	Unlimited Buck Permits Valid in 292	>10:100	None
302	2010-present	Unlimited Buck Permits	>10:100	None
318	2000-present	Unlimited Buck Permits	>10:100	None
319	2003-present	Unlimited Buck Permits	>10:100	None
329	2010-present	Unlimited Buck Permits	>10:100	None
335	2000-present	Unlimited Buck Permits	>10:100	None
339	2000-present	Unlimited Buck Permits	>10:100	None
343	2000-present	Unlimited Buck Permits	>10:100	None
380	2000-present	Unlimited Buck Permits	>10:100	None
390	2004-present	Unlimited Buck Permits (Portion of HD)	>10:100	None
391	2000-present	Unlimited Buck Permits	>10:100	None
392	2000-present	Unlimited Buck Permits	>10:100	None
400	Prior to 1972	Short Season	NA	None
401	Prior to 1972	Short Season	NA	None
403	Prior to 1972	Short Season	NA	None
406	Prior to 1972	Short Season	NA	None
640	2004-present	Short Season	NA	None

[1]Table does not include areas with weapon restrictions.
[2]In 2010 HD 250 went to limited permits.
[3]HD 260 AND 282 had restrictions but were not included in this analysis.
[4] Restrictive mule deer buck season included in analysis with HD 292.
[5] HD 298 was carved from HD 292 in 2008.

STUDY AREA

At the beginning of the 2011-hunting season 43 of 162 (26.5%) HDs or portions of HDs had some type of restriction on the harvest of mule deer bucks. Those 43 HDs encompassed approximately 24,126 square miles (sq. mi.) or 18.3% of the areas of the state open to deer hunting (Fig. 1). We evaluated data from 41 HDs with special regulations on the harvest of mule deer bucks: 11 with limited permits, 22 with unlimited permits, and 8 with a shortened season. HDs were therefore placed into one of the following four groups for this analysis.

1) Limited permit HDs were HDs where the numbers of permits for mule deer bucks could be adjusted annually. Hunters who held these permits could not hunt in any other HD in the state for mule deer bucks, however they could hunt anywhere in the state where their general license was valid for antlerless mule deer or white-tailed deer. Permit numbers were lowered if objectives for bucks were not being met or raised if objectives for bucks were exceeded.
2) Unlimited permit HDs were HDs where anyone that applied in the June 1 drawing would receive a permit, which allowed them to hunt in a specific HD or group of HDs for mule deer bucks. The hunter could not hunt a mule deer buck in any other HD, however they could hunt anywhere in the state where their general license was valid for antlerless mule deer or white-tailed deer.

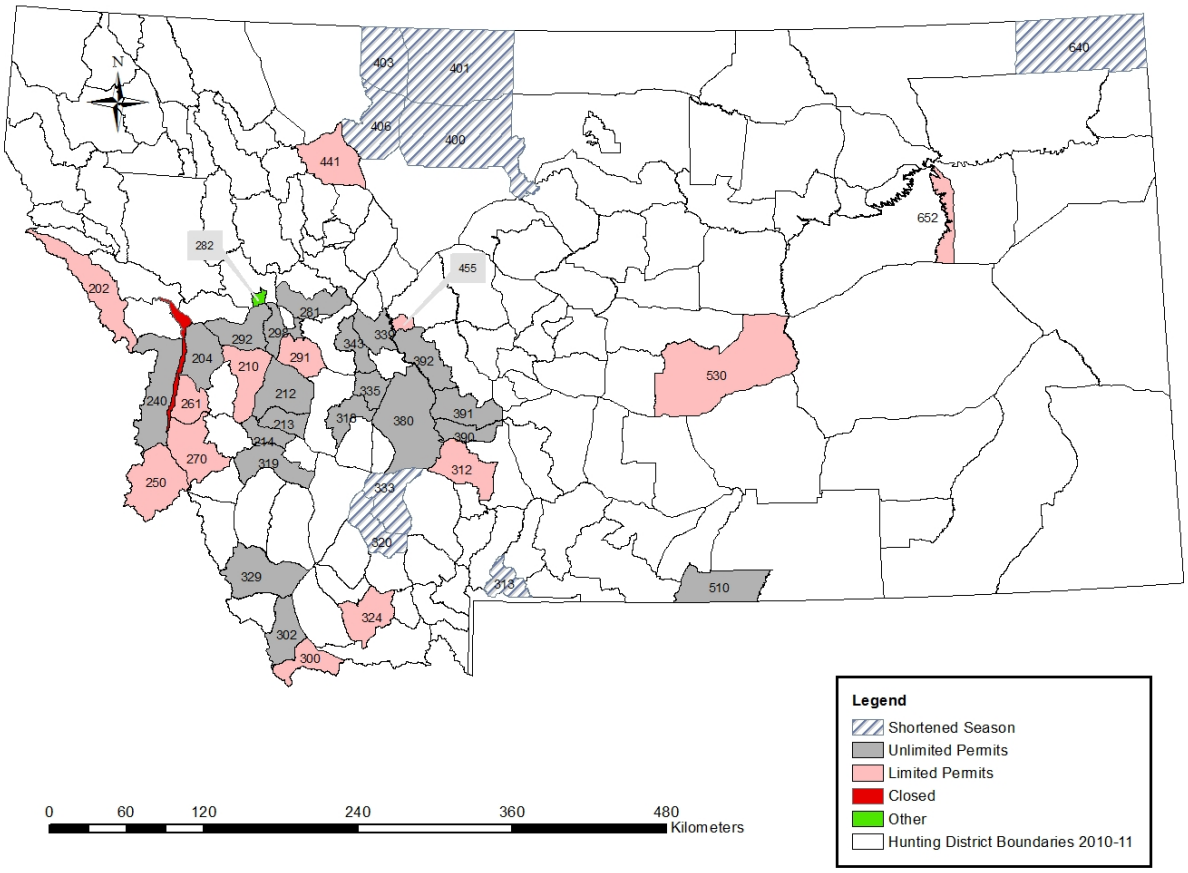

Figure 1. HDs with restrictive seasons on mule deer bucks, 2011. HD 250 changed from unlimited permits to limited permits in 2010 and was analyzed as an unlimited permit HD.

3) Shortened season HDs were HDs that had a shortened season but were open to all general license holders for hunting. All these HDs had a 23-day season in 2010, however shortened seasons in previous years varied in length. The purpose of the shortened season was to take hunting of mule deer bucks out of the rut.
4) Other HDs were all the other HDs in the state that had no special restriction on mule deer buck hunting. Anyone holding a general license could harvest a buck in most of those HDs.

METHODS

We analyzed data from 16 SMDs and 25 RSHDs (Table 3). There were two HDs (HD 260 and 282) that were not evaluated because the season structures for mule deer bucks were unique to those two hunting districts. HD 260 had no mule deer hunting, and in HD 282 hunters with a general deer license were also required to hold a 282-80 elk B-license or a 282-20 elk permit in order to hunt mule deer bucks during the rifle season. HD 250 had unlimited permits from 1999-2009 and limited permits in 2010 and was analyzed in the unlimited permit category. We censored several HDs, or specific years for specific HDs from the harvest and hunter participation data if the HD boundaries had changed significantly during the analysis period. When possible, we combined harvest statistics from HDs that had been combined or divided with a boundary change. An example of this was in HD 292. After 2008, HD 298 was created from HD 292 and small portions of other HDs. Although the new combined boundary was not exactly the same as prior to 2008, the

Table 3. Number of years of data in each HD for each response variable analyzed. Harvest information contains 6 response variables; hunter numbers, hunter days, total mule deer buck harvest, proportion of mule deer does in the harvest, and number of and proportion of 4 point or greater mule deer bucks (RSHDS and SMDs).

		Number of Years With Data While in Restrictive Season			
HD	HD Restriction	Buck:Doe Ratios	Fawn:Adult Ratios	Trend Counts	Harvest Information
202	Limited	6	8	9	13
204	Unlimited	0	0	0	12
210	Limited	5	3	3	13
212	Unlimited	0	0	0	4
213	Unlimited	0	0	0	4
214	Unlimited	0	0	0	4
240	Unlimited	0	0	0	12
250[2]	Unlimited	2	0	0	11
250	Limited	1	0	0	1
261	Limited	10	9	8	13
270	Limited	11	11	8	13
281	Unlimited	3	0	0	13
281	Unlimited	3	0	0	13
291	Limited	18	3	3	25
292MD[1]	Unlimited	8	9	9	11
292CF[1]	Unlimited	6	6	6	See 292 MD
298	Unlimited	Combined with data from 292			
300	Limited	12	13	6	12
302[3]	Unlimited	1	0	0	0
312	Limited	13	13	11	13
313	Short Season	10	13	13	11
318	Unlimited	0	0	0	11
319	Unlimited	7	8	6	8
320	Short Season	10	8	5	10
324	Limited	11	8	8	11
329[3]	Unlimited	0	0	0	1
333	Short Season	0	0	0	10
335	Unlimited	0	0	0	11
339	Unlimited	9	11	11	6
343	Unlimited	0	0	0	9
380	Unlimited	22	11	11	6
390	Unlimited	0	0	0	7
391	Unlimited	0	0	0	11
392	Unlimited	10	10	8	11
400	Short Season	27	2	29	16
401	Short Season	20	1	19	25
403	Short Season	30	2	28	25
406	Short Season	28	3	29	23
441	Limited	24	0	0	23
455	Limited	0	0	0	19
510	Unlimited	7	0	0	13
530	Limited	23	24	21	24
652	Limited	15	0	0	15
640	Short Season	7	7	7	4

Table 3. (cont)

HD	HD Restriction	Number of Years With Data While in Restrictive Season			
		Buck:Doe Ratios	Fawn:Adult Ratios	Trend Counts	Harvest Information
Total	Limited	149	92	77	182
Total	Unlimited	65	55	51	178
Total	Short Season	132	36	130	124
Grand	Total	346	183	258	484

[1]Harvest information for HDs 292 and 298 were combined for the period 2008-2010.
[2]In 2010 HD 250 went to limited permits, harvest information up until that time analyzed with the unlimited permit type.
[3]HD 302 and 329 went to unlimited permits in 2010.

local biologist felt that the harvests would be comparable pre and post change. We were not aware of any HD boundary changes that affected survey areas flown for mule deer. However, in some cases biologists had reduced trend areas in size, making total counts pre and post change incomparable, and we censored these data.

In several cases, HDs had restrictions on mule deer buck harvests prior to the 2011-season type. For example, most of the 200 and 300 HDs in Table 3 had a requirement to validate a hunter's general deer license prior to the time they could hunt in those HDs for the period 1997-1999. In HD 312, hunters were restricted to shooting a 2-point mule deer buck the last two weeks of the season for the period 1989-1998 along with requiring validation for the period 1997-1999. Although these earlier restrictions may have affected population and harvest parameters for those individual HDs, we chose to combine those years with the group of HDs with no restrictions

We summarized and analyzed harvest response variables for most HDs across the state and each of the HDs with restrictive buck regulations (Table 3). Population survey response variables were also summarized and analyzed for all restricted entry HDs where data was available. In addition to the SMDs and RSHDs, we compiled and analyzed corresponding population information for additional HDs that had no mule deer buck hunting restrictions (Table 4). Therefore, the impact of restricting mule deer buck harvest on each response variable was analyzed in a before-after-control-impact framework. This allowed pre- and post- comparisons for the response variables of interest within the SMD and RSHD districts, as well as comparison of the SMD and RSHD HDs to other HDs. The primary predictor variable of interest in all analyses was the season type, e.g., limited permits, unlimited permits or shortened seasons.

The number of years that response variables were collected, available and analyzed for each RSHD, SMD and other HDs were quite variable (Tables 3 & 4). Overall, we analyzed harvest data going back to 1986 and survey data going back as far as 1975-76 when data were available. Some HDs had surveys that were flown in both the post-season survey period, December-January, and the spring survey period, March-May. Post-season surveys measured buck:doe and fawn:doe ratios while spring recruitment surveys measured fawn:adult ratios and trends in populations on specific trend areas. Data on age by HD was not evaluated because we had a difficult time gathering enough age information to complete the analysis.

Statistical Methods

We used mixed-effects general linear models to examine the relationship between deer populations, harvest, hunter numbers and types of regulations at the HD level. The mixed-effects framework allowed us to partition variation within and among HDs in a repeated measures framework (Neter et al. 1996). We used these models to examine a wide range of aspects of deer populations and hunting by looking at 9 response variables: 1) proportion of male harvest with ≥4 antler points, 2) number of males harvested with ≥4 antler points, 3) proportion of harvest composed of antlerless deer, 4) total number of buck deer harvested, 5) number of hunters, 6) number of hunter days, 7) adult males per 100 adult females, 8) post-hunt fawns per 100 adult females, and 9) spring fawns per 100 adults. For each response variable, we fit 3 models. The first model included only a fixed trend effect of time and a random effect of HD. This model represented no effect of buck hunting restrictions. The second model contained a fixed effect for type of hunting restriction, a time

trend and a random effect of HD for each regulation type. This model represented a one-time change in the response variable as a function of restriction type. The third model contained a fixed effect for type of hunting restriction, a time trend, a time by hunting restriction interaction and a random effect of HD for each regulation type. This model represented a continuing change in the response variable as a function of the restriction type. The mixed-effects models allowed us to compare changes in the response variable as a function of changes in regulation while allowing each HD to differ in its overall mean response value. This allowed us to take advantage of the before-after information about hunting restrictions within a hunt district and across district differences at a single point in time. We fitted models in the statistics program R (R Development Core Team 2011) using the lme4 package (Bates et al. 2004).

We used AIC to select among the 3 models for each response variable. The model with the lowest AIC value was most supported by the data. We also examined parameter estimates and their variances to determine the quality of the model fit.

Table 4. Number of years of data available in HDs without buck restrictions for population response variables analyzed.

HD	HD Restriction	Buck:Doe Ratios	Fawn:Adult Ratios	Trend Counts
326	None	14	20	20
340	None	32	34	19
341	None	33	35	27
404	None	27	1	28
442	None	18	12	0
500	None	25	25	14
502	None	26	28	27
511	None	28	24	21
520	None	20	28	28
560	None	17	24	18
575	None	33	31	31
590	None	25	26	0
651	None	14	13	13
570CCR	None	23	25	15
570YBR	None	23	25	14
580BCR	None	22	20	20
580GR	None	28	29	21
Total	None	408	400	316

RESULTS

In limited permit HDs with an objective of 40 bucks:100 does, post-season, the objective was met or exceeded 36% of the time or in 20 of 55 HD-years (Table 5). HD 652 accounted for a majority of the years that this objective was met and when it was eliminated from calculations, the objective was met in only 6 of 34 HD-years or 17.6% of the time. In limited permit HDs with an objective of 25 bucks:100 does the objective was met or exceeded in 62 of 81 HD-years or 76.5% of the time. Over all HD-years with limited permits the buck:doe ratio was above 30:100, 47.0% of the time; above 20:100, 75.9% of the time; and above 10:100, 98% of the time (Table 6). In most cases the lowest buck:doe ratios were observed in the years immediately following the season change.

Two of the HDs with a shortened season had a post-season buck:doe ratio objective of 25:100, one had an objective of 15:100 and the rest had no specific objective for buck:doe ratios. For all the shortened season HDs the objective for buck:doe ratios was met in 9 of 20 HD-years (45.0%). The buck:doe objective in the HD with an objective of 15 bucks:100 does was met 60% of the time while the buck:doe objective in the HD with an objective of 25 bucks:100 does was met 30% of the time. Over all HD-years with a shortened season

Table 5. Number of years that HDs met objectives for buck:doe ratios.

		Number of Years With Data While in Restrictive Season			
HD	HD Restriction	Bucks:100 does Obj.	No. Years Obj. Met	No. Years Obj. Not Met	No. Years Unknown
202	Limited	40:100	1	5	6
210	Limited	40:100	0	5	6
261	Limited	40:100	2	8	3
270	Limited	40:100	3	8	2
291	Limited	40:100	0	8	5
300	Limited	25:100	3	8	2
312	Limited	25:100	9	4	0
313	Short Season	15:100	6	4	7
320	Short Season	25:100	3	7	0
324	Limited	25:100	7	4	0
333	Short Season	25:100	NA	NA	NA
441	Limited	25:100	23	1	0
455	Limited	20:100	NA	NA	NA
510	Unlimited	25:100	1	6	6
530	Limited	25:100	20	2	1
652	Limited	40:100	14	1	0
204	Unlimited	>10:100	NA	NA	NA
212	Unlimited	>10:100	NA	NA	NA
213	Unlimited	>10:100	NA	NA	NA
214	Unlimited	>10:100	NA	NA	NA
240	Unlimited	>10:100	NA	NA	NA
250[2]	Unlimited	>10:100	NA	NA	NA
250	Limited	>10:100	1	0	0
281	Unlimited	>10:100	NA	NA	NA
292MD[1]	Unlimited	>10:100	6	2	3
292CF[1]	Unlimited	>10:100	5	1	5
298[1]	Unlimited	Survey data combined with HD 292.			
302[3]	Unlimited	>10:100	1	0	0
318	Unlimited	>10:100	NA	NA	NA
319	Unlimited	>10:100	5	2	1
329[3]	Unlimited	>10:100	NA	NA	NA
335	Unlimited	>10:100	NA	NA	NA
339	Unlimited	>10:100	9	1	1
343	Unlimited	>10:100	NA	NA	NA
380	Unlimited	>10:100	NA	NA	NA
390	Unlimited	>10:100	NA	NA	NA
391	Unlimited	>10:100	NA	NA	NA
392	Unlimited	>10:100	NA	NA	NA
400	Short Season	NA	NA	NA	NA
401	Short Season	NA	NA	NA	NA
403	Short Season	NA	NA	NA	NA
406	Short Season	NA	NA	NA	NA
640	Short Season	NA	NA	NA	NA

[1]Combined survey information for HDs 292 and 298 for the period 2008-2010.
[2]In 2010 HD 250 went to limited permits, harvest information up until that time analyzed with the unlimited permit type.
[3]HD 302 and 329 went to limited permits in 2010.

the buck:doe ratio was above 30:100, 16.7% of the time; above 20:100, 42.5% of the time; and above 10:100, 79.6% of the time (Table 6).

The unlimited permit HD that had a buck:doe objective of 25:100 met that objective in only 1 of 7 years or 14.3% of the time. Most of the HDs with unlimited permits had an objective of maintaining at least 10 bucks per 100 does. In those HDs, there was a minimum of 10 bucks:100 does in 27 of 33 HD-years or 81.9% of the time. Over all HD-years with unlimited permits the buck:doe ratio was above 30:100, 0% of the time; above 20:100, 15.4% of the time; and above 10:100, 73.8% of the time (Table 6).

There were 15 HDs with data on buck:doe ratios that had no restrictions on buck harvest. Over all HDs and years with no restrictions, the buck:doe ratio was above 30:100, 5.9% of the time; above 20:100, 30.9% of the time; and above 10:100, 75.7% of the time (Table 6).

Table 6. Number of HD-years and percentage of years for specific buck:doe ratios by season type.

HD		Number Bucks:100 Does/%							
Restriction	HD-Years	0-9.9	%	10-19.9	%	20-29.9	%	>=30	%
Limited	149	3	2.0	33	22.1	43	28.9	70	47.0
Shortened	132	27	20.5	49	37.1	34	25.8	22	16.7
Unlimited	65	17	26.1	38	58.4	10	15.4	0	0.0
Other	408	99	24.3	183	44.9	102	25.0	24	5.9

Model Fitting

Of the three models tested, the model which contained a fixed effect for type of hunting restriction, a time trend and a random effect of HD for each regulation type, fit best for modeling the proportion of bucks ≥4 points and fawns:100 adults in the spring of the year. For one of the response variables, number of bucks with ≥4 points, the second best model was used because parameters in the minimum AIC model were poorly estimated (Table 7). For the number of hunters, number of hunter days, number of bucks harvested and bucks:100 does the model which contained a fixed effect for type of hunting restriction, a time trend, a time by hunting restriction interaction and a random effect of HD for each regulation type fit the best. In every case, models that contained an effect for season restriction out-performed the model with no effect for season restrictions.

Table 7. Results of AIC analysis. For each response variable, Delta AIC refers to the difference in AIC between the top model and the next most supported model. In one case the second most supported model was used to make inference, resulting in a negative value for Delta AIC.

		Intercept	
Response Variables	Delta AIC	Estimate	SE
Prop. Of Bucks ≥ 4 pts	13.40	0.43	0.01
Number of Bucks ≥4 pts	-5.00	145.98	16.48
Number of Bucks Harvested	16.95	322.60	25.22
Number of Hunters	28.83	1363.57	76.71
Number of Hunter Days	38.83	6231.76	408.33
Bucks:100 Females	10.88	14.91	1.71
Fawns:100 Adults	4.08	47.73	1.58

In this analysis there was a great amount of variability in values of the response variables across HDs and within years regardless of season type. For many of the response variables there was not a large difference across HDs or season restriction type. Three response variables, numbers of mule deer on trend areas in the spring, post-season fawn:doe ratios and proportion of female mule deer in the harvest were analyzed but were not reported on. Spring trend numbers performed poorly in the analysis, post-season fawn adult ratios followed a similar trend to, but were considered less important than fawns per 100 adults measured in the spring and the proportion of mule deer does in the harvest was affected by other factors besides restrictions on the harvest of mule deer bucks.

Proportion of Bucks≥4 Points

Only the limited permit season type had a greater proportion of bucks with ≥4 points in the harvest than HDs without restrictions. The shortened season and the unlimited permit seasons had an insignificant effect on the proportion of ≥4 point bucks in the harvest. There was a minor effect for year and the proportion of ≥ 4 point bucks in the harvest increased .007 bucks per year regardless of season type (Table 8).

Table 8. One-time effect of mule deer buck restrictions on response variables. In our analyses, HDs with no restrictions were treated as the base category, so the coefficients here should be interpreted as relative to HDs with no restrictions.

	Short Season		Limited Permits		Unlimited Permits		Year	
Response Variable	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Prop. Of Bucks >= 4 pts	-0.064	0.071	***.142***	0.03	0.02	0.02	***0.007***	.000
Number of Bucks >=4 pts	-19.61	40.91	***-40.48***	11.03	2.0	8.2	0.04	0.19
No. of Bucks Harvested	-86.43	54.05	***-101.39***	38.20	-88.11	51.50	**-4.39**	0.28
Number of Hunters	***-337.2***	151.7	-158.50	119.90	49.37	176.46	**-7.45**	0.85
Number of Hunter Days	***-1868.79***	957.59	-1381.80	719.73	1054.35	952.37	**22.59**	4.50
Bucks:100 Females	-4.26	3.18	4.89	3.51	7.94	6.06	**0.10**	0.04
Fawns:100 Adults	***13.54***	4.46	***9.62***	2.79	***7.01***	2.66	**-0.83**	.06

Bold italics indicate statistical significance.

Number of Bucks ≥4 Points

The number of bucks with ≥4 points was lower in the limited permit season type HDs than in the HDs with no restrictions. The shortened season, the unlimited permit seasons and year had insignificant effects on the numbers of ≥4point bucks in the harvest (Table 8).

Fawns:100 Adults

Even though statewide, fawn:adult ratios declined 0.83 fawns:100 adults per year throughout the period of study, there were significant increases in fawn:adult ratios in each of the restriction types. The strongest response was observed in the shortened season, where fawn ratios were higher by13.5 fawns:100 adults than HDs without restrictions. Limited and unlimited permit HDs had fawn ratios 9.62 and 7.01 fawns per 100 adults higher than HDs with no restrictions, respectively (Table 8).

Number of Bucks Harvested

All three restriction types and year showed a negative one-time loss in total buck harvest, however only the limited permit loss of 101.4 bucks and the year loss of 4.4 per year were significant (Table 8). The year/restriction interaction model indicated that following the initial loss in harvest all three restrictive season types showed an annual increase in buck harvest (Table 9) although only the shortened season trend was significant and greater than the annual loss of 4.4 bucks harvested per year (Table 8 and Table 9). We estimated that it would take approximately 15 years for shortened season HDs and 9 years for unlimited permit seasons to achieve a level of harvest comparable to HDs with no restrictions, however the number of bucks harvested in the unlimited season structure was poorly estimated (Fig. 2). Limited permit areas showed an initial loss in buck harvest of 101.4 bucks and an annual loss in harvest that was less than in seasons with no restrictions; however, it would take a very long time to achieve a level of harvest comparable to HDs without restrictions (Fig. 2).

Number of Hunters & Hunter Days

The shortened season HDs showed a significant one-time loss in hunter numbers (337.2) and days (1868.8) while the limited permit HDs showed an insignificant one-time loss in hunter numbers (158.5) and days

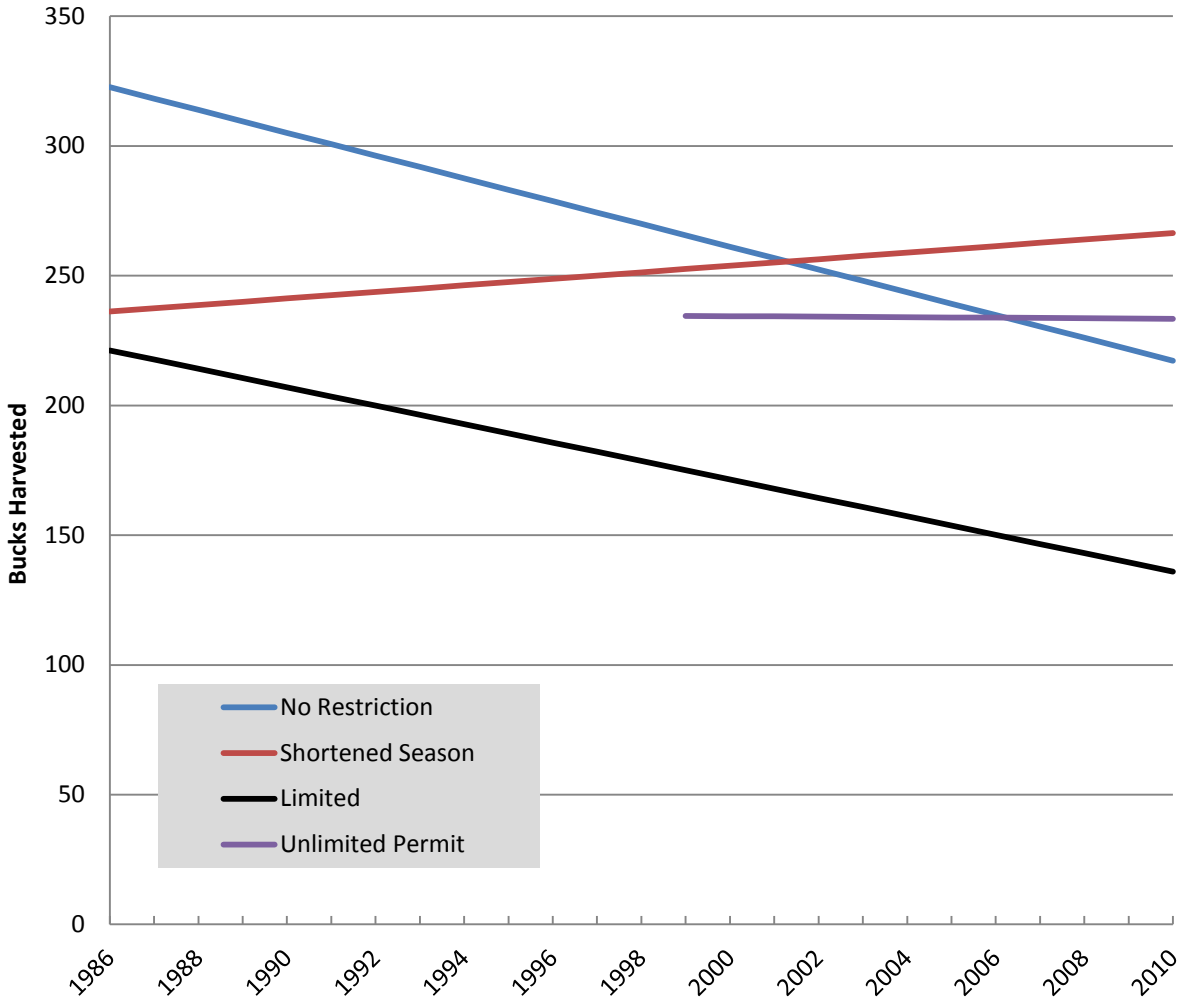

Figure 2. Predicted average effects of season type and year on mule deer buck harvest based on the best model, 1986-2011.

(1381.8) (Table 8). The unlimited permit HDs showed an insignificant increase in hunter number and days. Interestingly, hunter numbers have shown a significant annual decrease of 7.5 hunters per year per HD while hunter days have increased 22.6 days per year in HDs with no restrictions. The trends in hunter numbers and days following initiation of a restriction type were dependent upon that restriction type (Table 9). It appeared that hunters returned to HDs with shortened seasons at a much higher rate than to HDs with limited and unlimited permits (Figs. 3 & 4). Even though hunters returned to the shortened season HDs at a

Table 9. Effect of mule deer buck restrictions on the year coefficient in models including a time/restriction interaction. These coefficient values should be interpreted by adding them to the year coefficients in Table 8.

	Shortened Season		Limited Permits		Unlimited Permits	
Response Variable	Estimate	SE	Estimate	SE	Estimate	SE
Number of Hunters	***18.67***	5.2	-7.39	4.58	-14.23	8.56
Hunter Days	***84.01***	27.5	-37.12	24.35	***-118.44***	45.63
Number of Bucks Harvested	***5.66***	1.70	0.84	1.50	4.29	2.65
Bucks:100 Does	***.418***	0.10	***0.33***	0.13	-0.20	0.32

Bold italics indicate significance

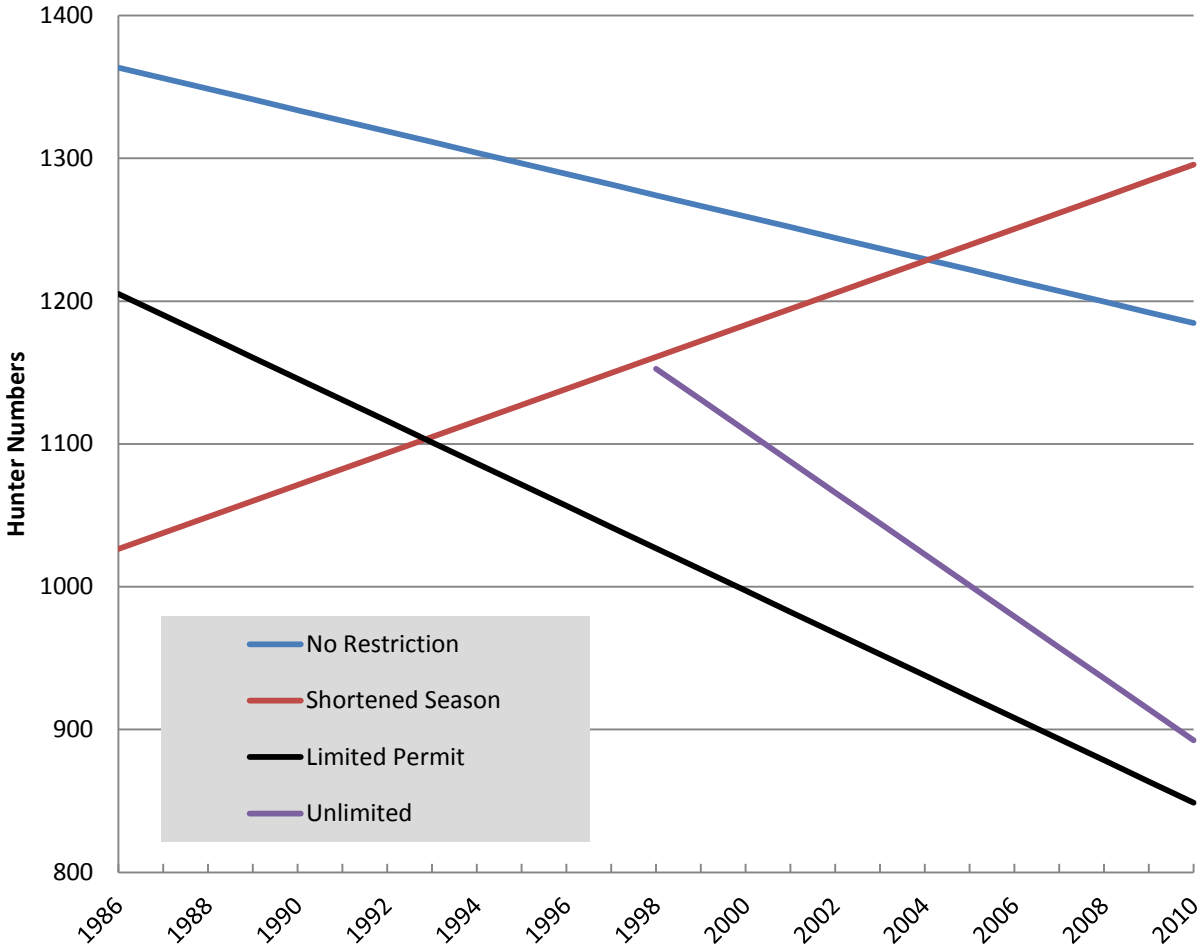

Figure 3. Predicted average effects of season type and year on hunter numbers based on the best model, 1986-2011.

higher rate we estimated that it would take nearly 20 years for hunter numbers and hunter days to increase to levels comparable to HDs without restrictions because of the large initial losses (Figs. 3 & 4). Although not well estimated the unlimited permit HDs showed the steepest decline in hunter numbers and days.

Bucks:100 Does

Because there was such great variation in the number of bucks per 100 does observed in individual HDs the one-time gains in buck:doe ratios following initiation of restrictive season types were poorly estimated (Table 8). However, there was an effect for year, and in general buck:doe ratios were increasing 0.10 bucks per 100 does annually in all HDs (Table 8). In addition to the effect of year there was an effect from a year/restriction interaction which indicated that buck:doe ratios increased significantly by .42 bucks:100 does and .33 bucks :100 does per year in the shortened season and limited permit HDs, respectively (Table 9). Although the estimate for buck:doe ratios in the unlimited permit HDs was not significant, it was the only restriction type that showed a weak decreasing trend in bucks:100 does with time (Table 9, Fig. 5)

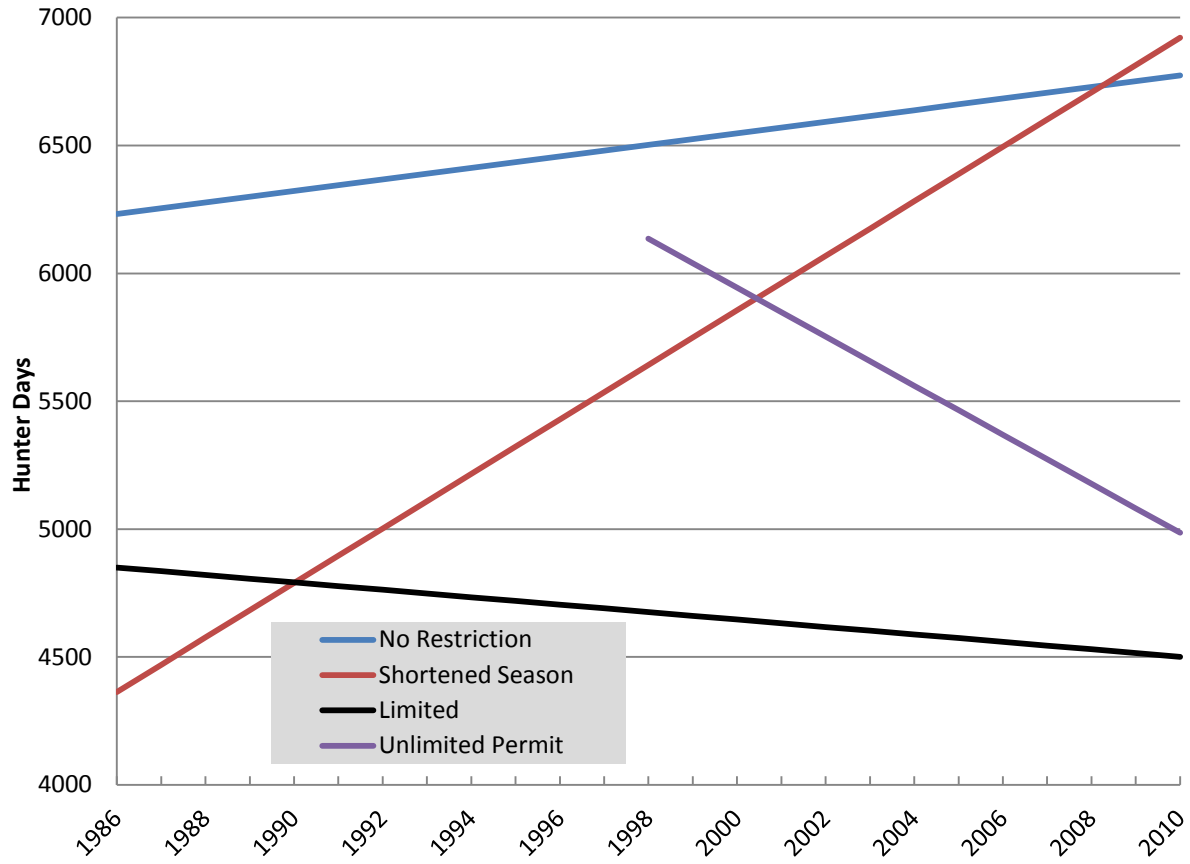

Figure 4. Predicted average effects of season type and year on hunter days based on the best model, 1986-2011.

DISCUSSION

It is a common practice for management biologists to compare one or two HDs in their areas of responsibilities when looking at the effects of season regulation changes on mule deer populations and harvest. However, we believe this may be the first time in Montana that data was analyzed on a statewide basis for multiple HDs with similar restrictions on mule deer bucks. Because of the great amount of variability among HDs, it was often difficult to detect differences between regulation types. In some cases meaniful results were masked by the high amount of variability.

Our results indicated that the mule deer buck season restrictions being used to achieve specific objectives worked in many cases. In those areas with limited permits, objectives of 25 bucks per 100 does or lower, were met in most years and in most HDs, however objectives of 40 bucks:100 does were not met in most HDs, especially in the western part of the state. It is possible that further reductions in buck permit numbers may help to increase buck:doe ratios. However, Pac and White (2007) suggested that managers would have a diffictult time improving numbers of mature males in the harvest in areas where mule deer coexisted with a diversity of large carnivores, as is the case in many HDs in the western part of the state. In most years, objectives of ≥10 bucks per 100 does, post-season, were met in HDs with unlimited permits but it would appear that achieving and sustaining ratios much higher than 10 bucks:100 does is unlikely with this restriction type. The shortened season restriction fell somewhere in between the limited and unlimited permit HDs, allowing for buck:doe ratios that were slightly higher than in HDs with no restrictions or unlimited permits but not nearly as high as some of the limited permit areas.

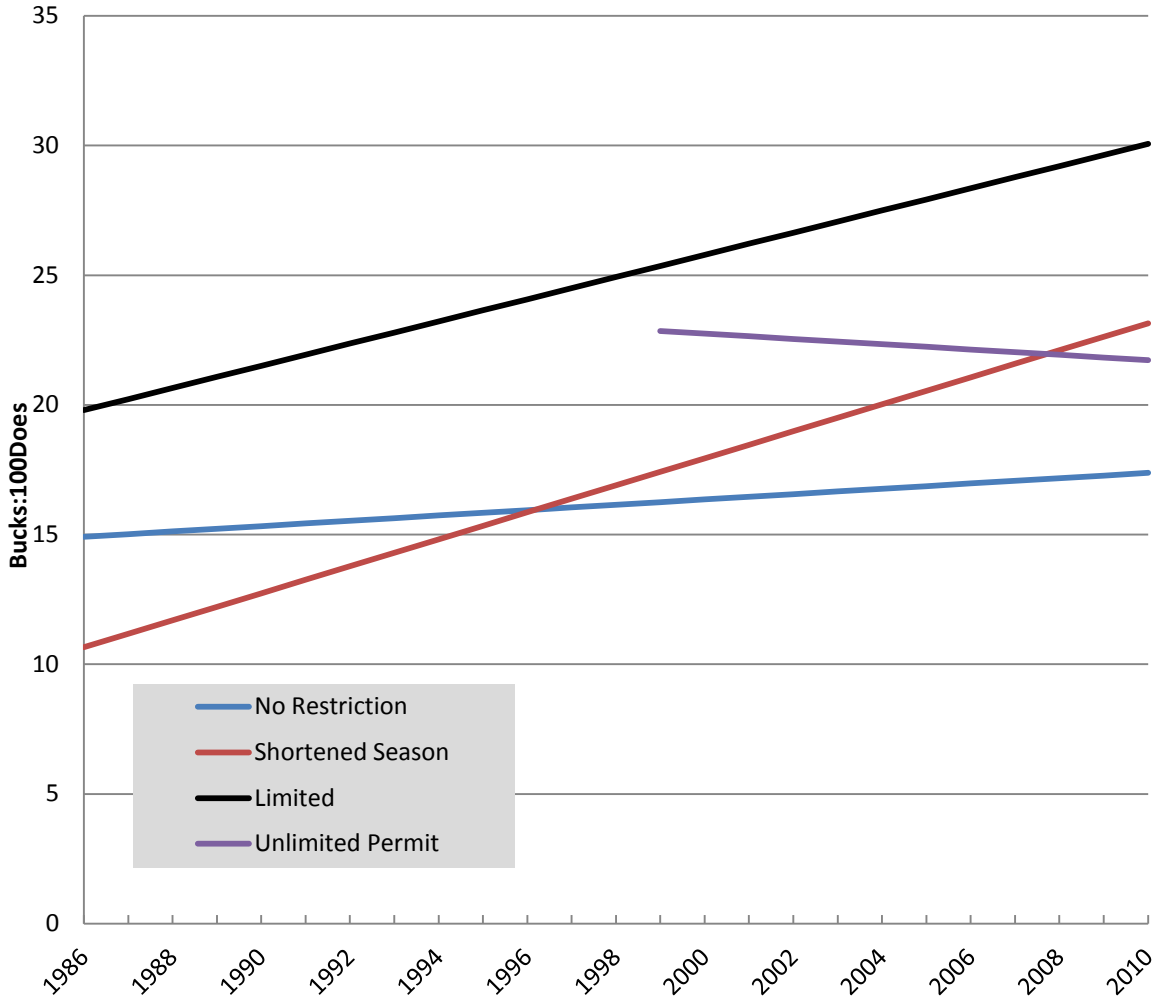

Figure 5. Predicted average effects of season type and year on buck:doe ratios based on the best model, 1986-2011.

Although the one-time loss in hunter numbers and hunter days was not very well estimated for any of the regulation types except the shortened season, the best model included a time by hunting restriction interaction. HDs with no restrictions, with limited permits and with unlimited permits all showed a downward trend in hunter numbers. The downward trend in hunter numbers was steepest for HDs with unlimited permits followed by limited permits. In the shortened season HDs there was a significant one-time loss in hunters however over time hunters tended to shift back to those HDs.

Hunter days on the other hand showed a slight decline in the limited permit HDs and relatively steep decline in the unlimited permit HDs. It is interesting, that hunter days increased in HDs with no restrictions even though hunter numbers decreased while in the shortened season HDs, hunter days and numbers both increased. We suspect that the hunter day increase observed in the unrestricted HDs may be a result of hunters having a more difficult time filling their deer licenses while in the shortened season HDs it was likely a result of more hunters using the area.

In Montana, Olson (1996) compared HD 441, a HD which allowed a general license holder to harvest a mule deer buck the first 3 weeks of the season and was on limited permits the last two weeks of the season to HD 442, an adjacent area with no restrictions. He found that hunter days and numbers increased at a higher rate

in 441 than in 442 over two time-periods 1979-86 and 1987-95. Similar to our results, Newell (1996) comparing pre (1975-1986) and post-change (1987-1995) hunter numbers and days in HD 530 found a significant loss in both parameters following the change to limited permits. The reason that HD 441 showed an increase while HD 530 showed a decrease in hunter use may be related, in part, to the fact that HD 441 had a portion of its mule deer buck season open to general license holders while HD 530 did not. Thompson (2007) compared hunter days generated in HD 640 when regulations were changed from a five-week either-sex season to a shortened season. Similar to our results, he found a significant decrease in the number of hunter days generated pre- (1999-2003) and post-change (2004-2006). Any changes in hunter numbers and hunter days across regulation types is influenced by the fact that most HDs with a restricted season type have whitetail populations, and in many cases a season on mule deer does that allow hunters to deer hunt within the HD. Montana harvest reports do not distinguish between hunter numbers and days generated by whitetail, mule deer doe or mule deer buck hunters, so the actual loss in mule deer buck hunter numbers and days may be much higher than reported here. In Colorado researchers did not estimate loss in hunters and hunter numbers following a statewide restriction in the harvest of mule deer bucks, however there was an immediate decline of 7.86 million dollars in annual revenue due to the reduction in deer license sales once mule deer buck harvest was restricted statewide (Bergman et.al. 2011).

Although there was not a large difference in the buck:doe ratios across regulation types, there was a large difference in trends across regulation types. Limited permit, shortened season and HDs with no restrictions all showed an increasing trend in buck:doe ratios with time. The shortened season type had the steepest slope followed by the limited permit season type and HDs with no restrictions. Although the trend was weak, unlimited permit areas showed a decrease in buck:doe ratios over time. Similar to the results reported here, Olson (1996) and Newell (1996) showed a trend towards increasing buck:doe ratios in HDs with limited permits following changes in regulations in HD 441 and 530. Likewise, Thompson (2007) saw an increase in buck:doe ratios in HD 640 as compared to HD 651 and 670 following a change to a shortened season, however he found that the increase was a result of increased survival of immature bucks, not mature bucks. Bergman et al. (2011) in Colorado saw significant increases of 7.39 to 15.23 bucks per 100 does in areas that they considered to be moderately limited and 17.55 to 21.86 bucks per 100 does increase in areas that they considered to be highly limited. Moderately limited in Colorado was much more restrictive than any of the limited seasons in Montana. It appears that increasing buck:doe ratios is a consistent result of limiting hunter opportunity via a random drawing or by shortening the season.

The number of bucks harvested in the no restriction and limited permit HDs decreased significantly over time at about the same rate. Following an initial loss in buck harvest in the shortened season HDs there was a gradual increase in buck harvest. On average we would estimate that 15 years following initiation of the shortened season regulation buck harvest would return to levels observed in HDs with no restrictions. In unlimited permit HDs there was no pattern of decrease or increase over time, although there appeared to be an initial loss in numbers of bucks harvested.

In all three restricted regulation HDs there was an increase in the observed spring fawn:adult ratios even though the general trend was for decreasing fawn:adult ratios of approximately 0.83 fawn per year across HDs with no restrictions. Although a reduction of .83 fawns:100 adults per year seems small, in a period of 20 years one could expect to see a reduction of nearly 17 fawns:100 adults. It is possible that the increasing fawn:adult ratios observed in the shortened season and limited permit HDs was a result of increasing buck:doe ratios. However, since the unlimited permit areas showed a decreasing buck:doe ratio and also showed an increasing fawn:adult ratio the relationship between buck:doe ratios and fawn:adult ratios is not clear. The increase in fawn recruitment in the restricted regulation HDs in Montana were in contrast to Bergman et.al. (2011), who found that fawn:doe ratios decreased by 6.96 fawns per 100 does following implementation of limited-entry hunting for mule deer bucks statewide. Researchers in Colorado speculated that there was circumstantial evidence to suggest that fawns were being replaced by bucks in the population. We did not see this type of compensatory response in Montana, however our observed buck:doe ratios were much lower than those observed in Colorado (P. Lukacs, formerly Colorado Department of Wildlife, personal communication). We believe that the difference between the declining trends in recruitment in HDs with no restrictions, and for the reversal of this trend in the SMDs and RSHDs, should be investigated further.

LITERATURE CITED

Bates, D. M., Maechler and B. Bolker. 2004. lme4: Linear mixed-effects models using S4 classes. R package version 0.999375-41. http://CRAN.R-project.org/package=lme4

Bergman E. J., B. E. Watkins, C. J. Bishop, P. M. Lukacs, and M. L. Loyd. 2011. Biological and socio-economic effects of statewide limitation of deer licenses in Colorado. Journal of Wildlife Management 75(6):1443-1452.

Montana Department of Fish, Wildlife and Parks. 2001. Adaptive harvest management: mule deer population objectives, hunting regulation strategies, special management districts, monitoring programs, population modeling, and deer management policies. Montana Department of Fish, Wildlife and Parks, Helena, USA.

Neter, J., M. H. Kutner, C. J., Nachtsceim, and W. Wasserman. 1996. Applied linear statistical models, fourth edition. WCB McGraw-Hill, New York, NY, USA.

Newell, J. A. 1995. An evaluation of mule deer buck hunting in HD 530, 1986-1984. Job Progress Report, Survey and Inventory, Deer, 1993-1995, Appendix 1, 23pp.

Olson, G., 1996. Mule deer hunting district 441. Internal memorandum, Montana Fish Wildlife and Parks. Great Falls, MT USA. 9pp.

Pac, D.,F. and G.C. White 2007. Survival and cause-specific mortality of male mule deer under different hunting regulations in the Bridger Mountains, Montana. Journal of Wildlife Management 71(3):816-827.

R Development Core Team , 2011. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org

Thompson, S., 2007. Results of an evaluation of a 3-week buck season in HD 640. Montana Department of Fish, Wildlife and Parks. Glasgow, Montana. 11pp.