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Factors influencing the efficiency of fixed wing aerial hunting for coyotes in the western United States

J. Russell Mason^{a,*}, William C. Pitt^a, Michael J. Bodenchuk^b

^aUSDA-APHIS-WS-National Wildlife Research Center, BNR-163, Utah State University, Logan, UT 84322-5295, USA

^bUSDA-APHIS-WS, P.O. Box 26976, Salt Lake City, UT 84126-0976, USA

Abstract

Aerial hunting is an effective tool for the removal of problem coyotes (*Canis latrans*). However, factors that predict hunt success remain largely obscure. To address this issue, we asked USDA-APHIS-Wildlife Services pilots in five western states to record meteorological data, ground conditions, and flight circumstances (e.g., purpose of flight, whether or not a ground crew was used) between December 1998 and August 1999. We obtained 426 flight records and evaluated them in relation to coyotes seen/h and coyotes killed/h of aerial hunting, with pilot as a covariate. Air temperature, resource to be protected, use of ground crew, degree of preventative control, cloud cover, snow cover, vegetative cover, wind direction, season, and lunar phase were significantly ($p \leq 0.05$) related to coyotes killed/h of aerial hunting. Variables that were not significantly ($p \geq 0.05$) related to coyotes killed/h were wind speed, steepness of terrain, barometric pressure and shotgun cartridge type. Our findings may have practical implications for increasing the efficiency of both aerial survey and aerial hunting operations important for coyote damage management. © 2002 Published by Elsevier Science Ltd.

Keywords: Aircraft; *Canis latrans*; Coyote; Hunting; Predation; Shooting; Wildlife damage

1. Introduction

The US Department of Agriculture (USDA) is directed by the Animal Damage Control Act of March 2, 1931 to protect American agriculture and other resources from damage caused by wildlife. Within the USDA, the Wildlife Services (WS) program meets this responsibility. One of the more controversial activities of WS is the protection of livestock, big game, and threatened and endangered species from predators, especially coyotes (*Canis latrans*). WS relies on a number of tools for the management of coyote depredation (Evans and Pearson, 1980; Wagner, 1988; Knowlton et al., 1999). Among these tools, aerial hunting remains an efficient means of removing animals responsible for damage (US Fish and Wildlife Service, 1978; Wagner, 1997). The method is particularly valuable when terrain is rough and/or when the areas to be covered are large and have limited access (Wagner and Conover, 1999a). Use of the technique is limited by expense, equipment availability, and environmental requirements for safe hunting (Wagner and Conover, 1999b). Aerial hunting operations are restricted to properties

for which WS has signed agreements permitting the activity from the land-owner (e.g., rancher, state or federal land management agency). The aircraft used for the purpose are Aviat A-1 Huskies and Piper PA-18 Super Cubs specially equipped for low level operations.

Apart from fiscal and equipment limitations, a number of other (chiefly environmental) variables may influence the number of coyotes killed/h of aerial hunting. These variables include coyote population size in the affected area, snow cover (for efficient tracking; C.J. Packham, unpublished report, 1973; Wade, 1976), and coordination with ground crews that help locate territorial coyotes (Wade, 1976). At least in terms of spring depredation on sheep, territory holders most often are the animals causing loss (Knowlton et al., 1999).

Empirical information concerning the importance of snow cover and other meteorological conditions are lacking. In the few studies, where weather conditions have been examined, the results have been equivocal or inconsistent with commonly held beliefs. For example, pilots often report that coyotes killed/h of hunting is greater during winter against a snow background. Although winter low level flying is safer than low level flying under warm conditions (Gantz, 1990), the single publication to discuss the importance of snow for aerial hunting success failed to

* Corresponding author. Tel.: +1-435-797-2505; fax: +1-435-797-0288.

E-mail address: Russ.mason@usda.gov (J.R. Mason).

identify any significant relationship (Wagner and Conover, 1999b).

To provide empirical information to improve the efficiency of aerial hunting operations, we conducted a preliminary investigation of variables influencing aerial hunting in Utah, USA during winter, 1998. That study suggested that barometric pressure, snow cover, vegetative cover, and lunar phase were correlated with coyotes killed/h of aerial hunting by fixed wing aircraft. We designed the present study to systematically investigate these and other potentially important variables. Nine fixed-wing USDA-WS pilots in five western states were asked to report weather and ground conditions encountered during aerial hunts. We also asked pilots to estimate the degree to which flights were corrective (occurring to stop ongoing depredation) or preventative (occurring before damage to prevent expected depredation), whether or not ground crews were used during hunts, and what kinds of resource (e.g., cattle, sheep, other) were being protected. We examined our data in relation to coyotes seen/h and coyotes killed/h of aerial hunting. We briefly discuss coyotes seen/h of hunting, but we only report in detail on the relationships between each of our variables of interest and coyotes killed/h of hunting.

2. Methods

2.1. Procedure

We designed a questionnaire to collect data about aerial hunt locations, ferry times to and from hunts, total flight durations, times of day that hunting occurred, type of flight (preventative to corrective), meteorology (wind speeds and direction at take-off, barometric pressure, temperature), extent of vegetative and snow cover, terrain, resource to be protected (sheep, cattle, sheep and cattle, other), use of ground crew, shotgun cartridge type (#4 buck, steel F, steel TT, steel T, BB), number of coyotes seen/h, and number killed/h of hunting. We distributed questionnaires to agency pilots in Wyoming ($n = 3$), Idaho ($n = 2$), Utah ($n = 2$), Nevada ($n = 1$), and New Mexico ($n = 1$), and asked that a copy be completed after each flight. Hereafter, we refer to pilots as Wyoming 1–3, Idaho 1 and 2, Utah 1 and 2, Nevada, and New Mexico.

We asked pilots to record type of flight, cloud cover, snow cover, vegetative cover and terrain as continuous variables using the method of magnitude estimation (Engen, 1972). Briefly, we asked respondents to mark 13 cm lines to indicate the degree of each of the five variables. Wind direction, temperature, and barometric pressure also were recorded as continuous variables. Otherwise, data were recorded as discrete variables (e.g., use of ground crew, resource protected).

2.2. Analyses

We used analyses of covariance (ANCOVA; ‘pilots’ was the covariate) to examine for relationships between the number of coyotes killed/h of aerial hunting and wind direction at take-off and landing, wind speed at take-off and landing, barometric pressure, temperature, flight time, ferry time, use of ground crew, resource to be protected, flight type (preventative to corrective), cloud cover, snow cover, vegetative cover, terrain, time of day and cartridge type.

We used analyses of variance (ANOVAs) to test for differences among aircraft, per se, in the number of coyotes killed/h of aerial hunting, coyotes seen/h of aerial hunting, wind speeds at take-off and landing, wind directions at take-off and landing, barometric pressure, temperature, ferry time, flight time, use of ground crews, resource to be protected, flight type, cloud cover, vegetative cover, and terrain type. We also used ANOVAs to examine coyotes killed/h of aerial hunting in relation to the resource(s) being protected, and the use of ground crews. Subsequent to the omnibus procedures, we used Tukey post hoc tests to isolate significant differences among means ($p < 0.05$).

3. Results

3.1. Number of records

We collected summaries for 426 flights between 28 December 1998 and 14 September 1999 (Table 1).

3.2. Coyotes seen/h among pilots

We found significant differences among pilots in the number of coyotes seen/h (i.e., total seen/(flight time minus ferry time) of aerial hunting; $F(8, 423) = 24.6$, $p < 0.0001$). Post hoc examination of differences among means indicated that Idaho 2 saw the most coyotes/h. Idaho 1 saw the next greatest number, albeit only slightly more than other pilots. The overall mean number of coyotes seen/h of hunting (\pm standard error of the mean) was 2.86 ± 0.35 .

Table 1
Flight records provided by each pilot

Pilot	Number of records	Dates of records	Number of hunters
New Mexico	81	01/19/99–09/14/99	4
Idaho 1	47	12/22/98–04/25/99	5
Idaho 2	38	01/04/99–05/11/99	2
Nevada	29	03/15/99–04/28/99	7
Wyoming 1	103	01/11/99–09/17/99	5
Wyoming 2	48	01/12/99–08/17/99	9
Wyoming 3	20	01/11/99–05/08/99	6
Utah 1	30	01/04/99–03/29/99	3
Utah 2	22	12/28/98–02/26/99	3

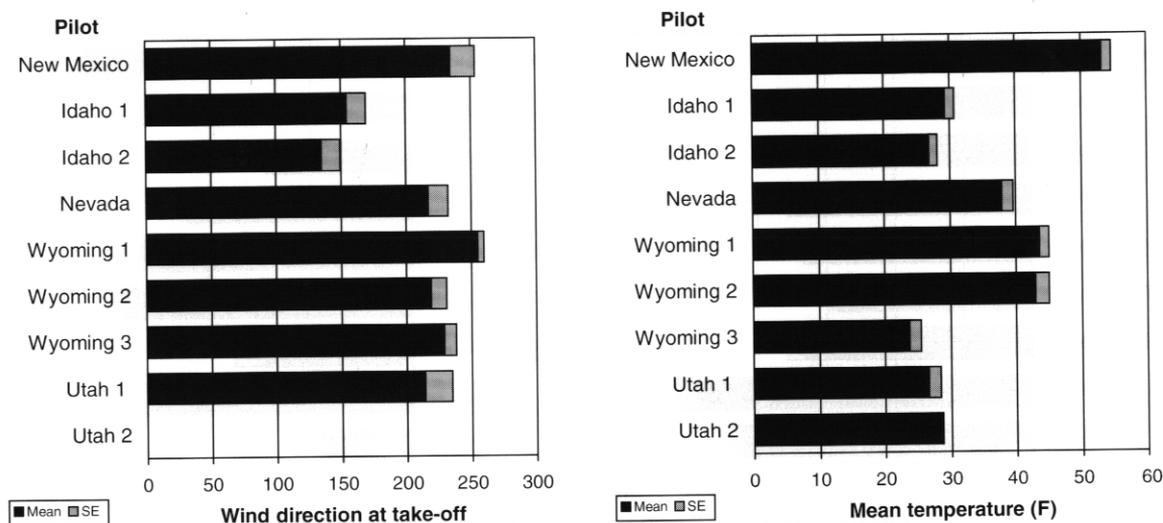


Fig. 1. (Left) Mean wind direction at take-off reported by different pilots. (Right) Mean temperature ($^{\circ}$ F) at take-off reported by different pilots.

3.3. Coyotes killed/h of aerial hunting among pilots

We identified significant differences among pilots in the number of coyotes killed/h (i.e., total kills/(total flight time minus ferry time) of aerial hunting; $F(8,417) = 19.7$, $p < 0.00001$). Post hoc examination of differences among the means showed that Idaho 2 (4.9 ± 0.5) had the most kills/h of hunting, followed by Idaho 1 (2.8 ± 0.3). We found that the other pilots were approximately equivalent on this variable, with kills/h of hunting ranging from 1.9 ± 0.19 to 1.2 ± 0.16 . The overall mean number of coyotes killed/h of hunting was 1.9 ± 0.09 .

3.4. Season

We found significant differences among seasons in the number of coyotes killed/h of aerial hunting ($F(2,32) = 21.0$; $p < 0.00001$). Our post hoc examination of the means revealed that significantly more coyotes were seen and killed during winter (0.23 ± 0.01), that intermediate numbers were seen and killed during spring (0.13 ± 0.01), and the fewest number were seen and killed during the summer (0.05 ± 0.006). Insufficient data were available to include fall hunting as a level of the factor.

3.5. Wind speeds

We found significant differences among pilots in wind speeds at take-off ($F(7,286) = 29.02$, $p < 0.00001$). Idaho 2 and Wyoming 3 reported significantly higher wind speeds at take-off than the other pilots. Wyoming 1 and New Mexico reported the lowest speeds. We also found significant differences among pilots in wind speeds at landing ($F(7,286) = 10.2$, $p < 0.00001$). Wyoming 1 reported the lowest landing wind speeds.

We failed to detect any overall relationship between wind speed at take-off ($p < 0.20$) or landing ($p > 0.40$) and coyotes killed/h of aerial hunting. Likewise, when aircrafts were considered individually, we did not detect significant relationships at take-off or landing.

3.6. Wind directions

We found significant differences among pilots in wind direction at take-off ($F(7,286) = 13.34$; $p < 0.00001$; Fig. 1, left panel). Idaho 1 and 2 took off into winds from the southeast. Other pilots generally reported take-offs into winds from the northwest. We also uncovered a significant negative relationship between wind direction at take-off and coyotes killed/h of aerial gunning ($p < 0.001$). However, because wind direction at take-off was confounded with pilot, we re-evaluated these data using an ANCOVA, treating pilot as a covariate. The results of this procedure again showed that wind direction at take-off was significantly related to coyotes killed/h of aerial hunting ($F(36,301) = 2.1$, $p < 0.006$; $F(32,322) = 2.5$, $p < 0.0001$, respectively). Pilots taking off into winds from the southeast reported more coyotes killed/h of aerial hunting.

3.7. Barometric pressure

We found significant differences among pilots in barometric pressures at take-off ($F(7,286) = 2.1$; $p < 0.05$). Nevada and Idaho 2 took off at pressures that were slightly, albeit significantly, less than those reported by other pilots. However, when we examined correlations between barometric pressure and coyotes killed/h of aerial hunting, we failed to find a significant overall relationship.

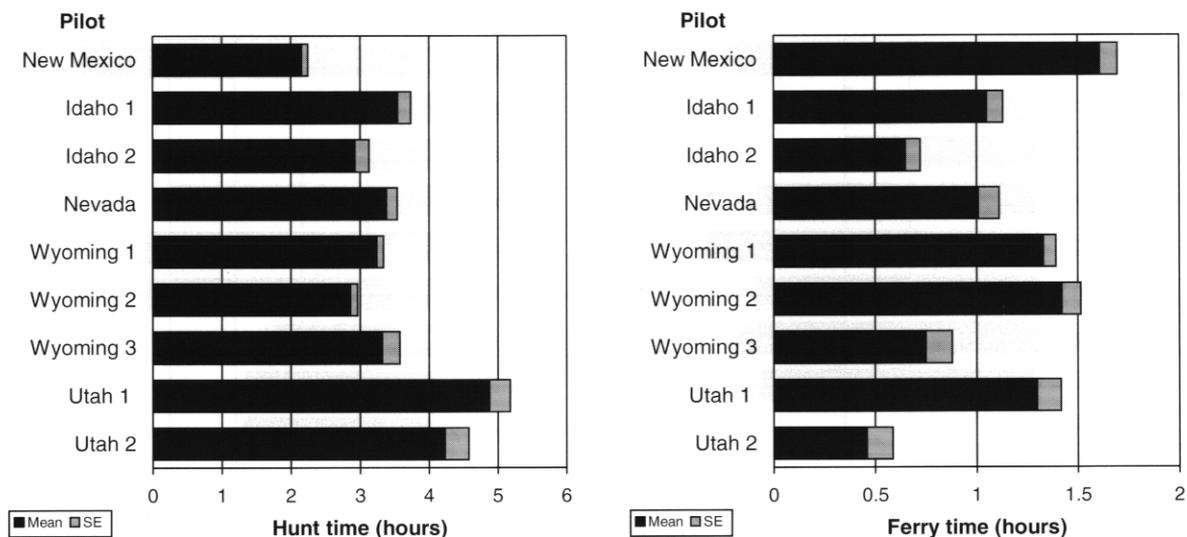


Fig. 2. (Left) Mean hunt durations reported by different pilots. (Right) Mean ferry durations reported by different pilots.

3.8. Temperature

We found significant differences among pilots in air temperatures at take-off ($F(7, 286) = 36.9$, $p < 0.0001$, Fig. 1, left panel). Idaho 1 and 2, Utah 1, Wyoming 3 took off at temperatures slightly lower than other pilots, while New Mexico took off at temperatures slightly higher than those reported by the others.

Overall, we found that higher temperatures were associated with fewer coyotes killed/h of aerial hunting. Because this result was potentially confounded with season and latitude, we re-analyzed using an ANCOVA, and treated season and pilot as covariates. We again found that temperature was inversely related to coyotes killed/h of aerial hunting ($F(65, 426) = 1.5$, $p < 0.01$).

3.9. Hunt and ferry times

We found significant differences among pilots in hunt durations ($F(7, 286) = 11.9$, $p < 0.00001$, Fig. 2, right panel) and ferry times ($F(7, 286) = 11.9$, $p < 0.00001$, Fig. 2, left panel). Idaho 1 and New Mexico reported slightly shorter hunt durations than the other pilots; Utah 1 reported slightly longer hunts. Idaho 1 and Wyoming 3 reported the shortest ferry times to hunting; New Mexico reported the longest ferry times.

We failed to uncover significant relationships, per se, between hunt or ferry times and coyotes killed/h of aerial hunting. However, because hunt and ferry times were confounded with pilot, we re-evaluated the data in an ANCOVA, treating pilot as a covariate. These analyses showed that both hunt ($F(65, 423) = 2.29$, $p < 0.00001$) and ferry ($F(34, 423) = 3.3$, $p < 0.0001$) times were significantly related to the number of coyotes killed/h of

aerial hunting. When we examined these effects, we found that shorter ferry times and longer hunts resulted in more coyotes killed/h of hunting.

3.10. Ground crews

We found significant differences among pilots in the use of ground crews ($F(7, 286) = 9.1$, $p < 0.00001$, Fig. 3, top panel). Idaho 1, Utah 1, and Wyoming 2 were slightly more likely, and Nevada slightly less likely, to use ground crews than the other pilots. Overall, $65 \pm 1.3\%$ of all flights employed ground crews to help locate coyotes. We also found that ground crews were more likely to be used during spring or summer than during winter ($F(3, 24) = 3.3$, $p < 0.039$; Fig. 3, bottom left panel), and that ground crew use differed among the types of resource to be protected ($F(3, 426) = 32.6$, $p < 0.001$; Fig. 3, bottom right panel). Crews were used most often during flights to protect sheep.

When we examined ground crew use in relation to coyotes killed/h of aerial hunting, we uncovered a significant negative overall relationship. However, because ground crew use was confounded with pilot and resource type, we re-evaluated the data in an ANCOVA, treating pilot and resource as covariates. We found that ground crew use remained significantly associated with coyotes killed/h of hunting ($F(1, 425) = 20.4$, $p < 0.001$). Fewer coyotes were killed/h of hunting regardless of pilot or resource, when ground crews were used (1.67 ± 0.05) than when they were not (2.42 ± 0.07).

3.11. Resources to be protected

We found significant differences among pilots in resources protected ($F(7, 286) = 4.3$, $p < 0.0001$; Fig. 4, top panel).

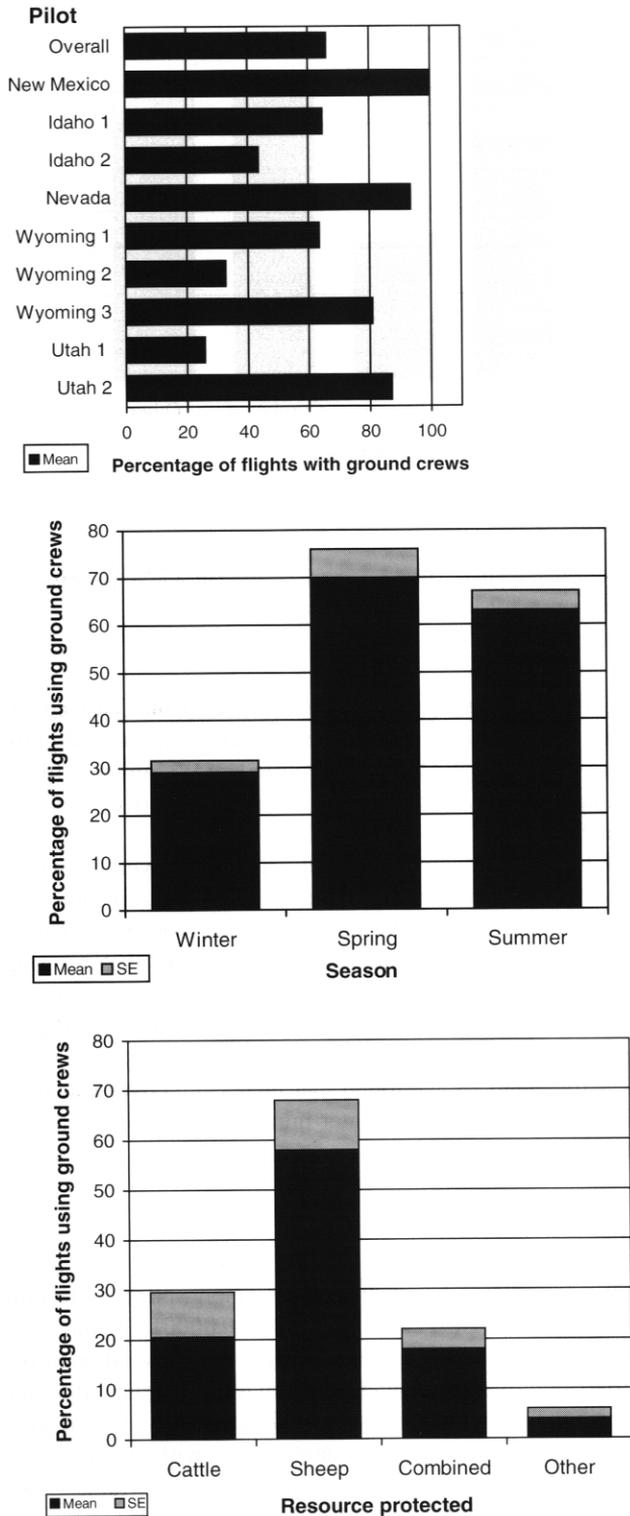


Fig. 3. (Top) Percentage of flights using ground crews, as reported by different pilots. (Bottom left) Mean percentage of flights using ground crews during different seasons; fall is not reported because the sample was insufficient. (Bottom right) Mean percentage of flights using ground crews, for the protection of cattle, sheep, combined resources (cattle and sheep), or other (e.g., wildlife resources).

New Mexico flew the most flights to protect cattle, followed by the Idaho pilots and Wyoming 2. Wyoming 3 and Utah 1 flew the least to protect cattle. Wyoming 1 flew the most flights to protect sheep while Utah 1 flew least for this purpose. Utah 1 flew the most flights to protect cattle and sheep as a combined resource; whereas Wyoming 3, New Mexico and Wyoming 2 flew the fewest times to protect both together. Utah 1 flew the most flights to protect other resources (e.g., mule deer, pronghorn) while New Mexico, Nevada, Idaho 2, Wyoming 3, and Utah 2 reported no flights for this purpose. Overall, sheep were the most commonly protected resource, followed by cattle, followed by sheep and cattle as a combined resource, followed by other resources (i.e., big game and/or threatened or endangered species).

When we evaluated resources protected in relation to coyotes killed/h of aerial hunting, we failed to uncover a significant overall relationship. However, because resource to be protected was confounded with pilot, we re-evaluated the data in an ANCOVA, treating pilot as a covariate. By this analysis, we found resource to be significantly related to coyotes killed/h of hunting ($F(3, 425) = 29.5, p < 0.001$); overall, fewer coyotes were killed/h of hunting when sheep was the resource being protected (Fig. 4, bottom panel).

3.12. Corrective versus preventative control

We found significant differences among pilots in the relative amount of time spent flying preventative control ($F(7, 286) = 6.6, p < 0.001$; Fig. 5, left panel). New Mexico and Wyoming 1 reported the least preventative flying. Wyoming 2, 3 and Utah 1 reported the greatest proportion of preventative flights.

When we also examined the relationships between aircraft, season, and type of control, we uncovered significant differences among aircraft ($F(8, 24) = 14.05, p < 0.001$) and seasons ($F(3, 24) = 3.3, p < 0.039$). Post hoc tests showed that Idaho 2 and Utah 2 were more likely to conduct preventative hunts than other pilots. Utah 1, and Wyoming 2 and 3 flew intermediate levels of preventative control, while New Mexico, Idaho 1, and Wyoming 1 were least likely to engage in preventative work. When we examined the difference among seasons, we found that preventative flying was more prevalent during winter; corrective flying was more common during spring and summer.

When we compared type of control with coyotes killed/h of aerial hunting, we uncovered a significant positive overall relationship. In particular, we found that coyotes killed/h was directly proportional to the degree of preventative control. Because preventative control was potentially confounded with pilot, we re-evaluated the data in an ANCOVA, with pilot as a covariate. We found that degree of preventative control remained significant ($F(63, 426) = 3.35, p < 0.0001$). The amount of preventative control attributed to a flight was positively correlated with the number of coyotes killed/h of hunting.

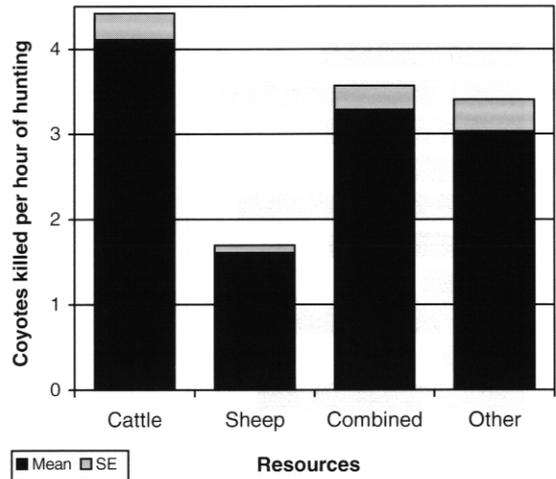
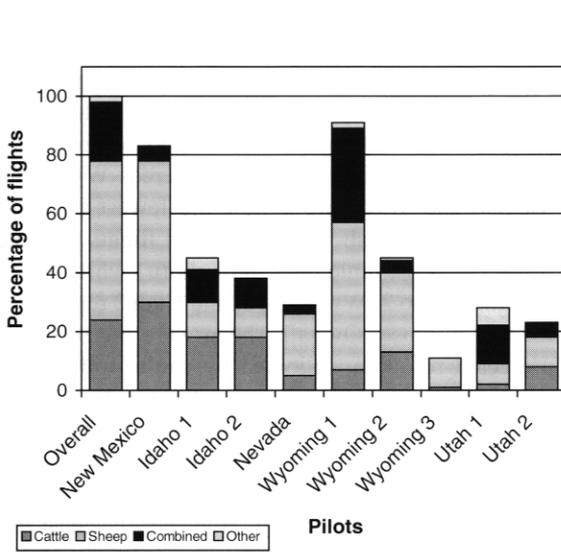


Fig. 4. (Top) Mean percentage of flights to protect various resources, as reported by different pilots. (Bottom) Mean coyotes killed/h of aerial hunting to protect cattle, sheep, combined resources (cattle and sheep), or other (e.g., big game or endangered species protection).

3.13. Clouds

We found significant differences among pilots in cloud cover during flights ($F(7, 286) = 15.5, p < 0.00001$; Fig. 5, right panel). New Mexico reported the least cloud cover during flights while Nevada reported the most. When we evaluated the relationship between coyotes killed/h and cloud cover in an ANCOVA with pilot treated as a covariate, we found that kills/h increased as cover increased from 0 to 60%, ($F(76, 426) = 2.08, p < 0.0001$).

3.14. Snow

We found significant differences among pilots in snow cover reported ($F(7, 286) = 6.43, p < 0.00001$; Fig. 6, left panel). New Mexico and Nevada reported relatively less snow cover than other pilots. Utah 1 and Wyoming 3 reported the most snow cover. When we compared snow cover and coyotes killed/h of aerial hunting, we uncovered a significant positive overall relationship. Because snow cover was potentially confounded with pilot, we re-evaluated relationships in an ANCOVA, treating pilot as a covariate. Snow cover remained significant ($F(88, 426) = 1.87, p < 0.0001$). Within the limits of flights reported (percent cover ranging from 0% for New Mexico to 47% for Wyoming 2), we found that increasing cover was positively related to increasing numbers of coyotes killed/h of hunting.

3.15. Vegetative cover

We found significant differences among pilots in vegetative cover reported ($F(7, 286) = 47.7, p < 0.000001$;

Fig. 6, right panel). Wyoming 2 reported the least cover. Utah 1, Wyoming 1, and New Mexico reported slightly more cover, but less than that reported by Wyoming 3, Idaho 1, Idaho 2, Nevada, or Utah 2. In all cases, cover was less than 50%.

When we compared degree of vegetative cover to coyotes killed/h of aerial hunting, we uncovered a significant relationship ($p < 0.05$). Because cover was confounded with pilot, we re-evaluated relationships in an ANCOVA, treating pilot as a covariate. Vegetative cover remained significant ($F(88, 426) = 1.87, p < 0.0001$). Within the limits of flights reported (percent cover ranging from 0% for Wyoming 2 to 47% for Idaho 2), we found that increasing cover was positively associated with greater numbers of coyotes killed/h of hunting.

3.16. Terrain

We found significant differences among pilots in terrain types reported ($F(7, 286) = 19.4, p < 0.00001$). Idaho 2 reported nearly flat terrain. Wyoming 1 and New Mexico reported slightly more broken (but still level) terrain. All other pilots reported terrain that was moderately hilly (i.e., magnitude estimates were approximately 50%), with the exception of Idaho 1; that pilot reported mostly steep terrain. There were no significant relationships between type of terrain and coyotes killed/h of hunting.

3.17. Cartridge type

We found significant differences among pilots in cartridge types ($F(8, 425) = 6.3, p < 0.012$; Table 2), and overall differences in the cartridge type used (4,425) =

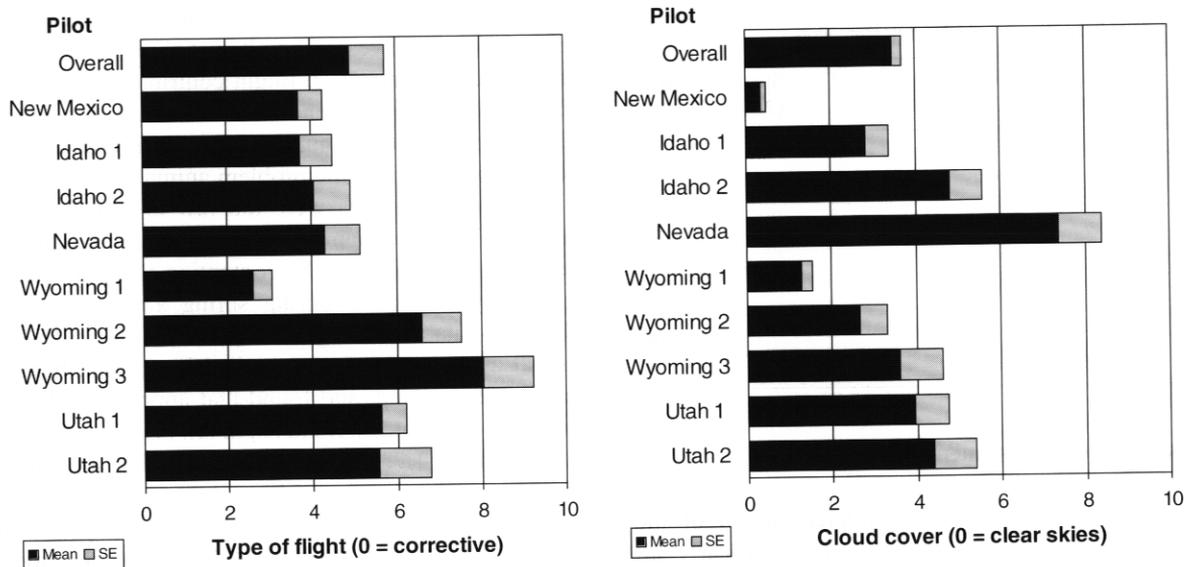


Fig. 5. (Left) Mean type of flying (corrective to preventative) flown by different pilots. (Right) Mean cloud cover (none to completely overcast) reported by different pilots.

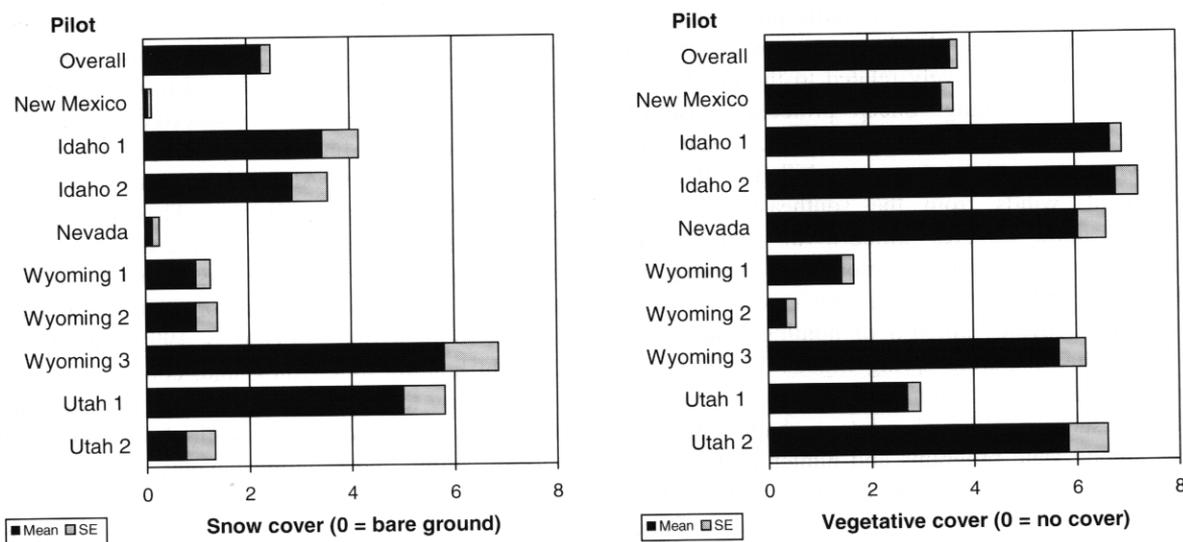


Fig. 6. (Left) Mean snow cover (none to complete) reported by different pilots. (Right) Mean vegetative cover (none to complete) reported by different pilots.

28.7, $p < 0.00001$). BB shot was most commonly used, then F steel, then buck shot, then TT or T steel. We were unable to identify any significant differences among cartridge types and coyotes killed/h of aerial hunting.

3.18. Time of day

We failed to find significant differences among pilots in the time of day of aerial hunts. All pilots flew most often in the morning, and the great majority of coyotes killed/h were taken during morning hunts.

3.19. Phases of the Moon

We found significant relationships between lunar phase and the number of coyotes seen/h of hunting ($F(3, 48) = 3.2, p < 0.05$), as well as the number of coyotes killed/h of hunting ($F(3, 48) = 2.8, p < 0.05$). The most coyotes were seen and killed on flights during days of full moons (0.16 ± 0.01). Although not statistically significant, intermediate numbers were seen and killed on flights during the first (0.14 ± 0.02) and last (0.14 ± 0.01) quarter moons, and the fewest were seen or killed during the new moon (0.05 ± 0.01).

Table 2
Shot sizes (and pellet caliber) used by different pilots

Pilot	Buck (24)	Steel F (22)	Steel TT (21)	Steel T (20)	BB (18)
New Mexico	100				
Idaho 1		100			
Idaho 2		100			
Nevada		48	34	7	11
Wyoming 1					100
Wyoming 2					100
Wyoming 3					100
Utah 1					100
Utah 2	96				4

4. Discussion and management implications

Our results indicate that pilots differed on all of the variables we examined, except time of day (nearly all flights occurred before noon). We believe this variability reflects regional differences in weather, topography, coyote populations, and other local factors. When we treated pilot as a covariate we found that longer hunts, shorter ferry times, cooler air temperatures, cattle protection, degree of preventative control, cloud cover, snow cover, and vegetative cover were positively related to the number of coyotes killed/h of hunting. Sheep protection, use of ground crews, and corrective control were negatively associated with the number of coyotes killed/h of hunting. In general, winds from the southeast were associated with more coyotes killed/h of hunting, as was hunting on days of a full moon and hunting in winter. Hunting conducted during a new moon was negatively related to coyotes killed/h of hunting, and fewer coyotes were killed/h during spring flights. Wind speed, barometric pressure and shotgun cartridge type were not related to hunt success (although pilots, perhaps reflecting differences among state programs and hunter preferences, did differ significantly in shotgun cartridge type preferences). Because wind speeds were recorded at take-off and landing, and not during hunts, per se, it remains possible that ambient wind speeds (and more importantly, wind gusts) could influence not only coyotes killed/h of effort, but also flight safety.

A number of our results are consistent with anecdotal observations. For example, animals may be less active on warmer days, thus making them less vulnerable to aerial hunting. Conversely, animals may be more active during cold weather and certainly, coyotes are easier to track and spot against a snow background, making them more vulnerable to aerial hunting operations. Our finding that the greatest number of coyotes were taken in winter and the fewest in spring/summer is consistent with our results that low temperatures and snow cover are positively associated with aerial hunting success. These results are inconsistent with the view that coyotes killed/h of aerial hunting simply reflects coyote abundance, per se. Coyote numbers

are probably highest in spring and decline through the remainder of the year (Knowlton et al., 1999). We speculate that other factors which might contribute to fewer coyotes being taken in spring and summer include the greater likelihood of corrective hunting and the presence of ground crews to locate specific problem animals.

Although our data were too few to examine fall hunts separately, evaluation of Utah WS program data provided additional support for the contention that aerial hunting is primarily corrective during spring and summer months, but preventative during fall and winter. We calculated seasonal averages for coyotes killed/h of aerial hunting over a two-year period, and found that approximately the same number of coyotes were taken in fall (1.84 coyotes killed/h) and winter (1.73 coyotes killed/h), that an intermediate number were taken in summer (1.33 coyotes killed/h), and that the fewest were taken in spring (0.73 coyotes killed/h). As we have noted, the type of hunting (corrective versus preventative) is related to the number of coyotes killed/h of hunting.

We did not expect to find that vegetative cover up to 60% was positively associated with coyotes killed/h of hunting. Conversations with pilots suggest that sparse cover is more productive for aerial hunting. Also somewhat unexpected was the finding that coyotes killed/h of aerial hunting was related to lunar phase. Hunts conducted during a new moon killed significantly fewer coyotes than hunts conducted on quarter or full moons. Although not statistically significant, kills/h was highest on a full moon. These differences among lunar periods may reflect the relative success of night hunting by coyotes. Prey may be less vulnerable or less available to coyotes during full moon nights (Falkenberg and Clarke, 1998; Jensen and Honess, 1995), resulting in more daylight hunting by coyotes, and, consequently, increased vulnerability to aerial hunting operations. Our findings on this factor also are consistent with observations of the success of calling and shooting coyotes for livestock protection; animals are more responsive to calls during days of a full moon (G. Littauer, USDA Wildlife Services, personal communication).

5. Conclusion

We conclude that lunar phase and a number of topographic and meteorological variables may be useful for predicting the effectiveness of fixed wing coyote hunting as well as other coyote management activities (e.g., counting animals from the air, aerial net-gunning; Bromley, 2000). Whether or not the present data may be useful for predicting coyotes killed/h of aerial hunting by rotary wing aircraft is unclear. We speculate, however, that if anything, significant effects for fixed wing aircraft would be even more pronounced for helicopters because rotary wing aircraft move more slowly over the landscape when hunting. This possibility remains a topic for further investigation.

Acknowledgements

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