Appendix E: Camp Williams Deer Management Plan

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CAMP WILLIAMS DEER MANAGEMENT PLAN

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Introduction:

The Camp W.G. Williams State Military Reservation (CW) supports a population of mule deer (*Odocoileus hemionus*) as part of its fauna. This population is currently not subject to legal hunting removals, and very little is known about its ecology or the impact of military activities. However various interactions with humans, notably highway mortality and on-going or proposed suburban development in areas adjacent to the installation underscore the need to obtain improved biological information and develop a management plan that is consistent with the military mission of this Utah Army National Guard (UTARNG) installation. This document attempts to accomplish the latter objective.

Deer Herd History and Habitat:

Relatively little information exists specific to the CW deer herd. Historically, the CW property was included as part of the Utah Division of Wildlife Resources' (UDWR) Herd Unit 20 (Heaston), but in 1997 that unit was incorporated into Herd Unit 18 (Oquirrh-Stansbury). The CW property comprises a small fraction (~10%) of this unit, the bulk of which lies on the western side of the Oquirrh Mountains and also the Salt Lake City metro area. Deer hunting on the CW property was terminated in 1986, following litigation ensuing from the death a person, who was killed by handling un-exploded ordinance. Military lands, specifically Camp Williams, have been designated as no hunting units since the late 1990's (e.g., VII (E) of the 2005 Big Game Proclamation).

. The CW property comprises three major vegetation types, sagebrush (*Artemesia tridentata*) - grass shrubland, Gambel oak (*Quercus gambellii*) woodland, and juniper (*Juniperus osteosperma*) woodland. These types comprise roughly 60%, 33% and 6%, respectively, of the total area of the training unit and are discussed elsewhere in detail (see Leidolf and Wolfe 2005, Hysell and Shultz 1995, INRMP 2001). However, these figures are based on data approximately 10 years old, and wildfires in recent years have likely wrought changes in species composition and structure within a community, but little conversion between plant community types (Johnson 1998). The juniper woodland forms a conspicuous community type on the western portion of the installation adjacent to the Oquirrh Mountains and on the eastern side of Tickville Gulch. Burned oakbrush stands have likely not undergone changes in species composition, but rather changes in density and stand structure (*cf.* Leidolf 2001): a landscape level assessment of LCTA data found that 66% of oak plots were in an early (shrub) stage, with 21% in a mid- or pole-size, and only 3% in late or tree-stage (Johnson 1998).

The UDWR has historically conducted range trend studies of the vegetation on key big game winter range areas at various locations throughout the state read at 5-year intervals. These "studies" consist of transects of permanently tagged plants of important browse species, the conditions of which is monitored at 5-year intervals. None of these sites are located on the CW property. However, the Manning Canyon site occurs within critical winter range at the extreme south end of the Oquirrh Mountains, between the municipalities of Cedar Fort and Fairfield at an elevation of ~1,670 m. That site is described as "essentially a pinyon/juniper big sagebrush/grass ecotone with moderate deer use", and as such likely makes it comparable to CW.

Although not documented exhaustively, CW probably serves as year-round habitat for a resident deer population, which is likely augmented numerically in winter by an influx of animals from the neighboring Oquirrh Mountains. On the basis of the vegetation composition described above and their relative importance to mule deer as determined from the relevant literature, I would rank the overall habitat quality of deer habitat on the CW installation as moderately good. With respect to cover value, juniper likely provides the best winter thermal cover, but the limited areal extent of this type restricts its overall utility. The cover value of oakbrush varies with respect to stand structure. Dittberner and Olson (1983) ranked the cover value of the Gambel oak type in Colorado, Utah and Wyoming as "good". However, tall dense stands of Gambel oak reach beyond the browsing height of deer and lead to shade-induced suppression of understory vegetation. In my view Gambel oak constitutes better summer thermal cover and security cover (especially during the fawning season) than winter cover.

In terms of nutritional value, sagebrush probably ranks highest and provides a staple winter forage base. The value of Gambel oak as a forage varies seasonally and with respect to plant age and burn status. As winter browse, Gambel oak is low in essential nutrients with crude protein <10% (Smith 1957, Kufeld et al. 1981, Welch 1989). The crude protein content generally does not meet the protein requirement of wintering mule deer. Juvenile Gambel oak contains higher tannin levels than mature trees, but also has higher digestibility of dry matter and fiber (Dick and Urness 1991). Concentration of tannins in Gambel oak forage is greatest in spring. Similarily, nutritional differences exist between Gambel oak sprouts on burned and unburned plants. While post-fire bud and stem tannin content is generally higher than unburned plant tissue, post-burn buds had a higher nutritional content than either buds or twigs of unburned areas (Tiedemann et al. 1987).

As described in detail by Leidolf and Wolfe (2005) the three major vegetative communities harbor a diversity of forbs and grasses and are interspersed with stands of other species of shrubs, which comprise a significant seasonal food source [browse] for deer. The most important of these are bitterbrush (*Purshia tridentata*), mountain mahogany (*Cercocarpus montanus*), and mountain x curl-leaf mahogany hybrids (*C. ledifolius* x *C. montanus*), as well as serviceberry (*Amelanchier utahensis*), chokecherry (*Prunus virginianus*), and snowberry (*Symphoricarpus oreophilus*). Undoubtedly, the understory vegetation associated with each of the three major vegetation types is important in the overall nutritional scheme of the CW deer herd. The same may be true of plants on agricultural croplands bordering the installation. Cheatgrass may comprise an important dietary component during green-up in late winter and early spring (Austin et al. 1994).

The questions of the extent to which mule deer require surface or free water and the animals' response to artificial water developments has been the subject of some controversy for over half a century (Anderson 1949, Broyles 1995 Hill and Bleich 1999). Much of the recent relevant research has been conducted with desert mule deer populations in the Sonoran Desert of Arizona and southern California (*cf*. review in Krausman 2002). This notwithstanding research in more temperate areas of the species' range by Hamlin and Mackie (1989) and Boroski and Mossman (1996), indicates that the distribution of water sources likely has an impact on habitat use by the animals, especially lactating females. Based on the results of these studies the investigators recommended an optimum spacing between water sources of <3.2 km.

At CW free water is available year round at Tickville Gulch, Oak Springs, Rose Creek, lower Beef Hollow and the Jordan River. Approximately 62% of the installation's area lies within 3.0 km of a source of free water (Table 1). Accordingly, availability of free water probably does not constitute a limiting factor for deer on the installation. However, as discussed below, deer crossing State Road (SR) 68 to water at the Jordan River [and forage in the adjoining riparian habitat and agricultural lands] likely represents a causal factor for the road-kill mortality occurring on that segment of the highway.

Table 1. Area and percentage of the CW installation at various distance classes from free water.

Distance (m)	Area (ha)	Percentage
200	1069858	1.1
500	2972721	3.0
1000	7299760	7.5
1500	10287745	10.6
2000	12932930	13.3
3000	25742458	26.4
4000	19428946	19.9
5000	14123540	14.5
6000	3609359	3.7
Total	97468354	100.00

Historically, the CW property was subject to fairly heavy grazing by domestic livestock (cattle and sheep), resulting in degradation of riparian areas and probable competition for forage between deer and sheep. However, this resource use is being phased out. Sheep (~1,500) were last grazed in 2002. As recently as 2002 and 2003, approximately 500 cattle were grazed summer-long (primarily in the Tickville Compartment). During 2004 and 2005, only ~250 cattle were allowed to "trail" through the installation.

Instrumentation is in place to measure snowfall on the installation, but the data are fragmentary. The closest permanent weather reporting station is in Riverton, and records from that station indicated a mean annual snowfall of 61 cm, of which 58% falls during the month of January. Casual observation does not suggest that winter mortality as the result of excessive

snow depths constitutes a significant problem in most years. The last significant winter mortality event occurred during the winter of 1992-93.

Biology:

Relatively little information exists pertaining directly to the CW deer herd, and much of this derives from the early and mid- 1990's. As discussed below, this period likely predates a combination of significant changes that may have resulted in increased decrements to the herd in recent years, including highway and predator mortality, loss of habitat due to suburban encroachment, and continuing drought conditions.

Movement and Home Ranges

Locations obtained from three radio-collared does indicated mean home range areas of 10.5 and 16.2 km^2 for summer and winter, respectively (Table 2). The locations of the home ranges for two of these animals are shown in Figure 1. To some extent the areas occupied by the animals reflect the locations where they were captured. However, the home range of one of these animals straddles SR 68, the implications of which are discussed below.

Table 2. Home range (HR) areas (km^2) of three radio-collared female mule deer from CW.

Deer ID	Summer		Winter	
	# Points	HR area	# Points	HR area
151.033	51	7.4	42	11.3
151.055	20	12.7	14	18.0
151.072	53	11.3	37	19.4
Means		10.5		16.2

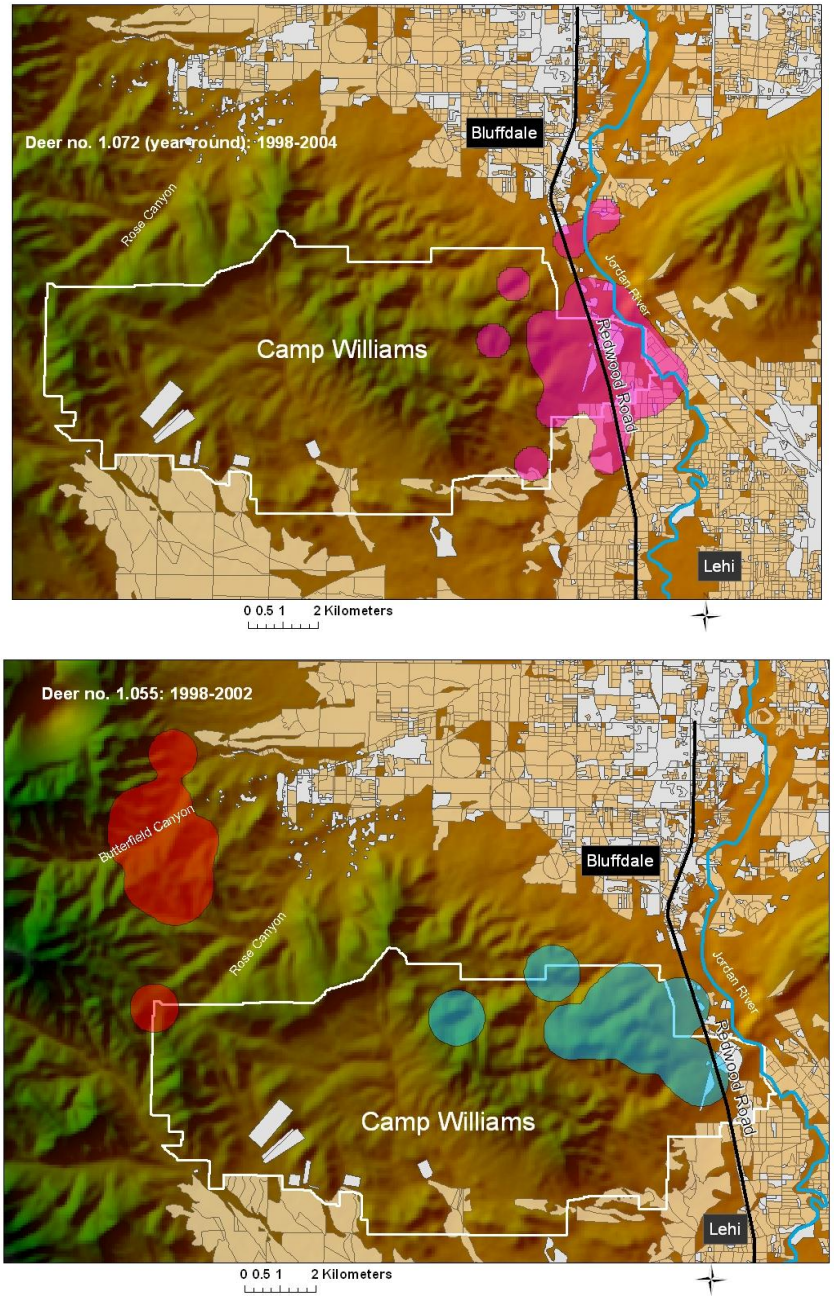

Figure 1. Home ranges of two does at CW as determined from radio-telemetry locations obtained from 1998-2002.

Productivity

Early winter herd classification counts were conducted in December 1992 and January 1997, with both counts involving sample sizes of <100. These surveys produced disparate estimates of herd productivity, namely 33 (s.d. = ±5.4) and 88 (s.d. = ± 6.2) fawns per 100 does, respectively (Table 3). Classification counts for the entire Oquirrh-Stansbury Herd Unit conducted during the time interval 1997/98 – 2000/01 indicated a mean of 59 fawns per 100 does, which is close to the average of the two CW estimates cited above.

Table 3. Mule deer herd classification counts conducted at Camp W.G. Williams

Date	Time of Day	Distance (km)	Effort (hrs.)	Males	Females	Fawns	Unknown	Fawns/100 ♀♀
12/16/1992	AM	41.6	2.3	0	48	16	2	33
1/7/1997	PM		2	2	34	30	2	88

A single, very crude, estimate of total population size on the installation derives from a single ground-based tally of ~2000 animals in March 1993 by R. Dunton. Even under ideal conditions counts of this nature typically underestimate the true population by a substantial margin. Fox example, Caughley (1977) calculated that ground-based counts of mule deer in Colorado conducted over good snow conditions and reported by Gilbert and Grieb (1957) accounted for only about 58% of the actual population. This suggests that at the time of Dunton's survey, the actual CW population may have been in excess of 3,400 animals. Although not corroborated by empirical evidence, it is my subjective assessment the current population lies below this level.

Mortality Factors

Collisions with vehicles constitute a significant source of mortality for the CW deer herd. Kassar and Bissonette (2005) analyzed Utah Department of Transportation (UDOT) records on highway mortality on Route 68 for the period 1992-2002. During this period there were 252 reported deer collisions over the total 71-mile (113.6-km) length of this highway, resulting in an overall average collision frequency of 3.6 collisions per mile (2.2 collisions per km). A collision "hot spot" occurred within the 6-mile segment between mile markers 34 and 39, accounting for 187 collisions or 74.2% of the total and an average of 2.8 collisions/mile/year (Fig. 2a). This segment corresponds to the Jordan Narrows segment of the highway that borders CW. Various studies have shown that actual number of deer killed on a given highway exceeds reported highway strikes by a factor ranging from 4-6 (Kassar and Bissonette 2005, Aoude 2005) to as high as 10 (P. Cramer, personal communication). Extrapolation based on these figures, produces an estimate of between 102 and 170 deer that are killed annually on this highway segment.

In a sample of 164 road-killed deer tallied by Dunton (personal communication) between October 1996 and July 1999, adult females and adult males comprised 81.6% and 6.1% of the total. Fawns and yearlings are probably underrepresented in this sample due to the lower detection probability of the former age class and possible misclassification of age in the latter. In a smaller sample (n = 25) of deer examined opportunistically along Route 68 during 2004 and 2005 females, males and fawns comprised 56, 24 and 20%, respectively, of the animals examined (Stoner, unpubl. data).

In May 2004 UDOT convened a workshop to identify major sections of Utah highways that function to disrupt the connectivity of wildlife habitat, noting also the safety hazards posed by roads as the prima ry threat to connectivity. In a draft report released in June 2005 West (2005) identified the Jordan Narrows segment of SR 68 as a high priority segment with deer as

the principal species of concern. The report noted that signs and flashers have not served to rectify the situation.

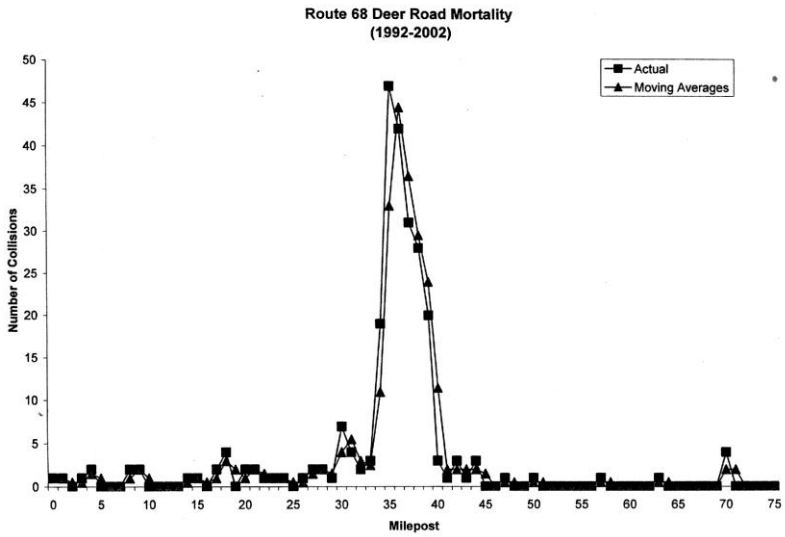

Figure 2a. Number of deer-vehicle collisions reported by UDOT on SR 68, 1992-2002, showing a collision "hotspot" between mile markers 34 and 39, where the highway transects the CW installation (Graph from Kassar and Bissonette 1995).

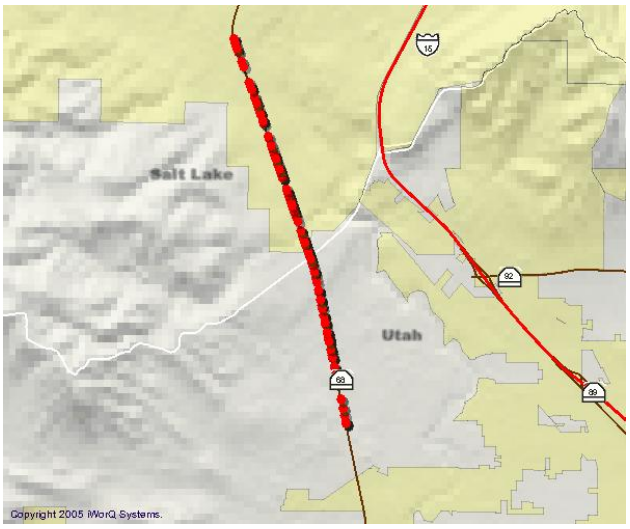

Figure. 2b. Detail of deer-vehicle collisions on the segment of SR 68 adjoining and traversing the CW installation.

A reduction of predator control efforts directed at cougars (*Puma concolor*) and coyotes (*Canis latrans*) by Wildlife Services personnel at CW during recent years has likely had an impact of unknown magnitude on the deer herd. Although not directed specifically at the predation issue, the results of an ongoing investigation of cougars by Utah State University personnel permit limited inferences about the impact of these animals on the deer population. We computed crude estimates of predation rates, based on radio-telemetry data obtained from cougars equipped with GPS collars. The computational procedure for these estimates follows that described by Anderson and Lindzey (2003) and constitutes the product of the estimated seasonal number of cougars present on the installation, the mean daily predation rate and the number of days in each "season". Based on locational data, "winter" (5 months, December - April) and "summer" periods (7 months, May - November) were estimated to comprise 151 and 214 days, respectively. The mean estimated number of adult cougars present on the installation in winter during the period 1997-2005 was 4.3 animals, but appears to have increased slightly since 2003 (Fig. 3). The number of cougars inhabiting the installation during the summer period remained relatively constant at ~2 animals.

These computations yielded estimated winter and summer predation rates of 0.137 and 0.092 deer per day, respectively (Table 4). Applying the above predation rates yields estimates of 20.7 and 19.7 deer killed per cougar for the two periods, respectively. The estimated total number of deer (28) killed during the summer is straight forward. Using three different scenarios for the number of cougars present in winter (4-6) produced estimates varying from 83 to 124 animals. Accordingly, the total annual mortality of deer estimated as being attributable to cougars ranges from 111 to 152 animals.

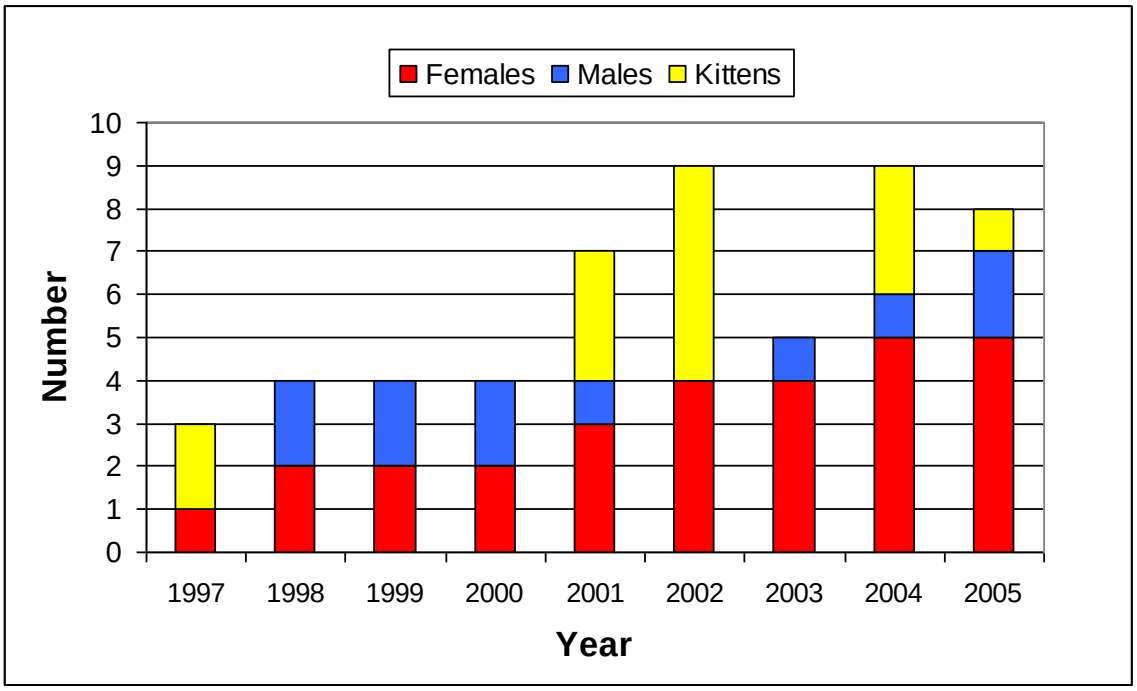

Figure 3. Estimated winter numbers of cougar at CW, 1997-2005.

Table 4. Estimated seasonal cougar predation rates at Camp Williams.[a]

Winter Predation (December – April)				**Summer Predation (May – November)**			
Cougars present[b]	Predation Rate	Days	Deer mortality	Cougars present[b]	Predation rate	Days	Deer mortality
4	0.137	151	82.7	2	0.092	214	27.8
5	0.137	151	103.4				
6	0.137	151	124.1				

[a]Calculated as the product of the seasonal number of cougars present * daily predation rate* length (in days) of the "season")
[b]Assuming adults only with a sex ratio of 4♀♀:1♂

A total of 37 carcasses were examined from mule deer killed by cougars on the CW installation. Of these, males and females comprised 35% and 32%, respectively with animals of unknown gender accounting for the remainder. Adult animals comprised the largest fraction (51%) of the sample, with yearlings and fawns accounting for an additional 19% and 11%, respectively. The ages of an additional seven (18.9%) animals could not be determined.

The CW installation may serve as a "magnet" for poaching because of the relative permeability of its boundaries and the fact that there is no legal hunting, which could result in a degree of stockpiling of older and larger-antlered bucks. Range Control personnel at CW handle an average of 3-4 deer poaching incidents annually, but systematic records are not kept and this figure is undoubtedly an underestimate of the potential number of deer lost to this factor.

Summarizing the above indicators of mortality, I estimate that the total annual decrements to the CW population lie within the range of 250-300 animals, which is likely sufficient to produce a numerically stable or slightly down-trending level.

Impact of Military Training Activities:

Much of the existing literature applicable to the effects of military activities is focused on noise (e.g., Krausman et al. 1993). This literature has been effectively reviewed by Larkin (1996: appended). The conclusions of this review are somewhat equivocal, and the author notes methodological limitations resulting from small scale studies, anecdotal reports, the paucity of directly relevant studies, and problems of appropriate experimental design. Only one of the studies cited in the review (Freddy et al. 1986) dealt specifically with mule deer, and that study investigated the animals' response to humans on snowshoes as opposed to snowmobiles. These caveats notwithstanding, it is probably worthwhile to summarize the salient generalizations of this review:

(1) Risk of hearing damage in wildlife is probably greater from exposure to blast noise (e.g., from large weapons) than from long-lasting exposure to continuous noise or from muzzle blast of small arms fire;

(2) Behavioral effects that might impact fitness (i.e., probability of survival and reproduction) include displacement from quality habitat near noise sources and reduction of foraging time with attendant nutritional impact;

(3) Documentation of negative impacts on fitness is difficult;

(4) Decreased responsiveness following repeated noises is frequently observed and usually attributed to habituation.

Beyond these putative impacts, Stoner (personal communication) reported finding at least two deer at CW that appeared to have died from shrapnel. [Incorporate time frame!]

One of the few studies to employ a valid experimental approach (Stephenson et al. 1996) evaluated behavioral responses of 71 radio-collared mule deer to military activity on the Piñon Canyon Maneuver Site in southeastern Colorado. The study area consisted of subunits that were subject to training activities on a rotational basis. The investigators observed larger home ranges among fawns and does in maneuver areas than in non-maneuver areas. Female deer also exhibited a greater frequency (40.0%) of home area shifts than those (12.5%) in non-maneuver areas. The researchers suggested that deer in the active training zones may have responded to harassment, alteration of security cover, or destruction of the forage base.

Doxford and Judd (2002) noted that the impact of training is highly variable and dependent on location, timing and intensity of training. Based on their broader typology of environmental impacts, those associated with wildlife (specifically deer) include: (1) direct disturbance as the result of excessive noise and traffic generation; and (2) a plethora of disturbances to the supporting habitat, including soil compaction/erosion, destruction of vegetation and increased fire frequency. The authors analyzed the potential advantages and disadvantages of several alternatives to traditional methods of army training on dedicated ranges using live, full-caliber ammunition. The alternatives included training using sub-caliber ammunition and a variety of simulation approaches. Their analysis focused on the training requirements of artillery systems. The authors concluded that virtual reality (VR) simulation provided the most potential benefits in comparison to the other alternatives analyzed. However, VR cannot completely replace the value of real-world training experiences.

Management

Goals and Objectives:

Considering the implications of the management issues discussed below, it appears that the future portends greater insularization of the CW deer herd with or without proactive management. The overarching goal for management of the CW deer herd is the maintenance of

a population level that is in balance with its habitat and minimizes negative interactions on areas adjacent to the reservation. In the light of safety concerns and potential litigation, hunting should be considered as a tool to accomplish this goal rather than as end in and of itself only if and when the population exceeds land capacity.

Unfortunately, specifying a population size that defines this level constitutes a conundrum, precisely because we do not know the current size of the CW deer population. Absent obvious quantifiable signs of habitat damage (e.g. evidence of over-browsing) it is not possible to state whether the population exceeds the carrying capacity. Despite a voluminous literature on the species, reliable estimates of actual or optimal densities in habitats comparable to those a CW are virtually non-existent. Unlike hunted populations throughout the state there exists no known off-take to use as a starting point for population modeling efforts. The necessity of adequate methods of population enumeration is discussed in greater detail below under Informational Needs.

An alternative, albeit less sophisticated, approach would be that of monitoring the level of forage utilization by deer, in particular winter utilization on key browse species. Various procedures have been described to obtain indices of utilization, but these fall into two general categories, namely (1) difference methods and (2) grazed-plant methods (Cooperrider 1986). The former approach typically involves comparison of average twig lengths in paired samples of plants subject to browsing and those protected from browsing (e.g., caged). The second method entails an annual two-stage sampling effort in which measurements of the average leader length are made prior to and following the winter browsing period. The index of utilization would be the percent difference between the mean twig length obtained from the respective measurements. In either case it would be important to monitor the level of utilization on an adequate sample of plants from several locations on the winter range. Other essential considerations include those of selecting the appropriate species to monitor and defining the level of utilization that might trigger efforts to reduce the deer population. In the past, utilization >75% of CAG has been used as an upper limit of acceptable utilization, but it should be noted that utilization levels may vary annually as well as from site to site depending upon winter severity.

Authority and Responsibilities

Federal Authority. − The salient [federal] legislative instrument governing wildlife management on Army National Guard installations is the Sikes Act, passed in 1960 (16 U.S.C. §670 *et seq*.) and most recently reauthorized in 2003. This act mandated each military department to manage natural resources on military reservations under it Secretary's jurisdiction "to the extent not inconsistent with the military mission of the reservation," with the additional conditions of providing for sustained multipurpose uses of those resources and the public access necessary or appropriate for those uses. In the case of CW public access is demonstrably inconsistent with the military mission due to safety concerns related to current training and unexploded ordinance (UXOs). Each military reservation is directed to develop a cooperative plan (Integrated Natural Resources Management Plan (INRMP) with the appropriate state agency in which the reservation is located (see below).

Pursuant to this mandate U.S. Army Regulation 200-3 (AR 200-3) of 1995 sets forth "…responsibilities, policies and procedures to wisely use, scientifically manage and systematically restore renewable natural resources existing on Army lands consistent with the local military mission, national security, and current Federal laws pertaining to renewable resources and the quality of the environment." The applicability of this regulation extends to federally owned State Army National Guard operated installations. As set forth in Chapter 6-4a of this regulation, the central element is a Fish and Wildlife Cooperative Plan that provides for:

(1) Fish and wildlife habitat improvements or modification;

(2) Wildlife considerations in all range rehabilitation;

(3) Control of off-road vehicle traffic;

(4) Endangered Species Management Plans (ESMP's) for listed and proposed species and critical habitat improvement projects and related activities;

(5) Use and protection of fish and wildlife resources to include both consumptive- and non-consumptive use, and natural resources law enforcement requirements;

(6) Designated responsibilities for the control and disposal of feral animals.

As prescribed in Chapter 7-1d, public access to Army properties for the purpose of recreation is subject to its compatibility with public safety and mission activities.

Chapter 11-4b specifies that Army installations must be sensitive to those species listed as endangered or threatened under state law, but not federally listed. Although there is no requirement for ESMP's for State-listed species, installations are directed to cooperate with State authorities in efforts to conserve these species, and the cooperative plans should identify State-listed species and specify agreed upon conservation measures.

Hunting on military reservations and facilities falls under the ambit of 10 U.S.C.A §2671, which in subsection (a) (1) specifies that this activity be in accordance with the fish and game laws in which the facility is located. This requirement includes that of a valid state hunting license as per subsection (a) (2). Pursuant to subsection (b) the Secretary of Defense may waive or otherwise modify applicable laws of the state in the interest of public health or safety at the installation. This authority includes that to extend but not reduce the hunting season, but does not extend to waiving the requirement of a license and fee imposed by the state. In practical terms this means that installation managers may curtail or prohibit hunting on the reservation, but if permitted it must conform to state licensing requirements.

There also exists legal precedent embodied in case law (*Hunt v. United States*, 278 U.S. 96, 1928) that would permit a federal landowner to undertake herd reduction activities by its own managers pursuant to the property clause of the constitution, if the animals are deemed to be damaging the habitat. Finally, as is the case with any other landowner, the UTARNG should be able to charge a trespass fee for access to its land.

State Authority. − In July of 2005 the UDWR submitted a final draft of a Comprehensive Wildlife Conservation Strategy (CWCS) to comply with the requirements of the State Wildlife Grants (SWG) program created by Congress in 2001. The purpose of this program was to provide federal funding to support conservation aimed at preventing wildlife from becoming endangered and in need of protection under the Endangered Species Act (ESA). To address wildlife species in the CWCS, the UDWR adopted a three-tiered system that prioritizes the state's native animal species according to conservation need. Tier I includes federally listed species for which a Conservation Agreement has been completed and implemented. Tier II species include species listed on the Utah Species List under sole state authority. Tier III species includes species that are of conservation concern because they are linked to at-risk habitats, have suffered marked population declines, or where available information on the ecology or status of the species is insufficient. By virtue of region-wide population declines, mule deer meet one of the criteria for classification as a Tier III species.

Future Management Issues:

Suburban Development. — Ongoing and proposed residential development of former agricultural and wildland areas adjoining the borders of CW pose potential problems in terms of deer-human interactions. One consequence would be the dimunition of the habitat available to the animals, especially in winter, which may in turn result in overutilization of the forage resources on residual portions of the animals' range. In severe cases this could produce some overwinter mortality in the deer herd. This putative effect would likely be most pronounced during severe winters when snow depths on the lower elevation portions of the installation exceed 50 cm (Gilbert et al. 1970, Bartman et al. 1984). Harassment by domestic dogs from residential areas could conceivably exacerbate winter stress and result in possible mortality (Lowry and McArthur 1978). Other possible consequences include browsing damage to ornamental plants in residential areas and cases of cougar-human interactions when cougars follow deer into developed areas. Whereas the former is largely a nuisance factor, public intolerance and safety concerns play a role in the latter.

Highway Mortality. — The proposed Legacy Parkway (~Mountain View Corridor) will run from Nephi to Brigham City, and a segment of the route will be adjacent to the CW property, effectively reducing SR 68 to a frontage road. Predicting the potential impact of this highway development on the magnitude of highway mortality is problematical. Subject to important constraints discussed below, some insight might be gained by analysis of UDOT traffic volume statistics. Average daily traffic volume (ADTV) measures for the segment of SR 68 in the vicinity of CW for the year 2003 indicate 8,850 vehicles per day. A comparable statistic for I-15 near Point of the Mountain was nearly 120,000 vehicles per day. Assuming that at full development the new highway might divert 20% of the ADTV from the I-15 corridor, it is possible that traffic on the segment adjoining CW might see a doubling in the current volume of SR 68, subject to a higher posted speed limit. Kassar (2005) reviewed the literature on relationships between traffic volume and/or posted speed limits and the number of wildlife-vehicle collisions. The results of these studies yielded disparate results, and in her own case study involving four state routes in Utah, she found no significant relationship between "events" and these variables. She discussed the problems involved with the manner in which traffic

volume data is collected. These limitations not withstanding, it appears reasonable to predict that in the absence of mitigative measures, the frequency of deer-vehicle collisions will likely increase following installation of the Legacy Parkway.

An underlying maxim of U.S. jurisprudence pertaining to wildlife is the "doctrine of *ferae naturae*" and the traditional interpretation thereof that the individual states (including their regulatory agencies) cannot be held liable for injuries caused by indigenous wild animals. From this doctrine flows the general principle that a landowner cannot be held strictly liable for the acts of *ferae naturae* on his property. *Prima facie* this would appear to absolve both UTARNG and UDOT from potential liability for the consequences of wildlife vehicle collisions occurring on SR 68 or the future Legacy Parkway. However, as evidenced by recent litigation (Booth v. Arizona), this traditional interpretation does not exclude claims of negligence when wild animals pose a recognized hazard to motorists and the appropriate state agency fails to undertake measures to remediate the problem. The above-mentioned case is currently in the process of adjudication (i.e.appeal) and the ultimate outcome remains uncertain. This notwithstanding, it may be prudent for UTARNG and UDOT to calibrate in devising measures to alleviate deer-vehicle collisions.

Probably the most appropriate strategy would be fencing combined with underpasses at key locations. Two considerations speak against immediate implementation of this recommendation. First, it would appear ill-advised to fence SR 68 at the present time, if it is only to become a frontage road with probable reduction of traffic and presumably collision frequency pending construction of the Legacy Parkway. Secondly, with the exception of the existing tunnel under SR 68, appropriate locations for installation of additional underpasses are unknown. The most logical solution would be to incorporate fencing and underpass structures into the construction plan for the Legacy Parkway. This would permit a period of study, possibly with radio-collared animals to determine locations that would be best suited for the underpasses.

Informational Needs:

As explained in the attached research prospectus (Appendix I), the essential informational elements requisite to credible management of a deer population are reliable estimates of (1) population size; (2) juvenile recruitment into the population; and (3) juvenile and adult survival rates. Of these, population size is probably the most critical. Probably the best approach is to use aerial quadrat sampling (Freddy et al. 2004). We have proposed to the UDWR that the Oquirrh-Stansbury Deer Management Unit be used as one of 4-5 core units to be enumerated on a 3-5 year rotational basis. Conceivably, this will allow cost sharing between the UDWR, UTARNG, and possibly Kennecott Utah Copper.

Herd composition surveys
Standardized counts of sex and age represent a widely used method of obtaining indices of herd productivity and in some instances over-winter fawn survival (Rabe et al. 2002). Some authors (Downing et al. 1977, McCullough 1993, McCullough et al. 1994) have cautioned about the use of indices obtained from composition counts because of inherent variability and bias resulting from several factors including animal behavior, misclassification and observational

inconsistencies. McCullough (1993) noted that replication can improve precision but likely no correct biases. However, these sources of error are most prevalent in the case of animals inhabiting denser cover such as white-tailed deer (*O. virginianus*) and black-tailed deer (*O.h. columbianus*). The technique is currently used by most Western state wildlife agencies (Rabe et al. 2002), and the UDWR has standardized procedures for conducting herd classification counts. With appropriate training CW personnel should be able to obtain annual estimates of productivity and over-winter fawn survival. This training could be acquired by means of a field-based workshop conducted by either UDWR or USU personnel.

Composition counts should be conducted "pre-winter", in December. Timing is important to preclude misclassification of bucks [as does] that have lost their antlers with does. The use of ATV's should enable access to maximize the areal coverage of these surveys. It is recommended that the location of each counting point be geo-referenced and the distance to the cluster of animals being classified be measured with laser-range finding binoculars.

Differentiation of young of the current year (i.e., fawns) from adult animals constitutes one of the major potential biases encountered in late winter and early spring composition surveys. Although it becomes increasingly difficult to distinguish differences in body size and confirmation between juveniles and adults as the season progresses, certain facial characteristics can be used to facilitate the process. Viewed in profile, the face of fawns generally appears shorter than that of mature animals with a blunter angle of the lines formed by the forehead and the lower jaw. This short, blunt profile makes the ears of fawns appear considerably longer in relation to the face than for adults. In addition, the neck of immature dear appears shorter and heavier that that of older animals. These and other differences in body confirmation are relatively subtle in nature and require considerable practice to apply with any degree of reliability. Any one of them by itself may not be sufficient for differentiation of juveniles from adults, but taken together they may provide a kind of "signature" that may be useful.

The question arises as to how many animals should be sampled. The usual assumption is that greater sampling effort will produce more precise results. Apart from constraints on time and/or, optimum sample size is dependent upon several factors, three of which are of primary importance: (1) the approximate size of the population being assessed; (2) the apparent ratio in question; and (3) the desired precision for the estimated ratio. Czaplewski et al. (1983) developed a chart (Fig. 4) developed that provides recommended sample sizes for various apparent population sizes as a function of various population sizes. Use of the chart is illustrated by the following example. Line A indicates that a minimum of 500+ observations should be made in a population numbering between 2,000 and 3,000 animals. For an observed age ratio of 50 fawns:100 does, the precision corresponding to curve A is ±7:100. This implies that if classification counts of that sample size were replicated 100 times from the population in question, the true value of the ratio would fall between 43 and 57:100 in 90 of the trials.

Additional Information

A radio-telemetry or mark-resight study would yield potentially valuable information for managing the CW deer herd, including: (1) survival rates; and (2) movement patterns. The latter information would help define what fraction of the installation's deer herd moves on and/or off the unit seasonally as well as potential locations for future highway underpass structures. An

investigation of this nature would not be inexpensive, because it would likely involve capture of a sizeable number (30+) of deer probably by means of helicopter netting-gunning as well as the costs of collars and monitoring efforts. If UTARNG personnel were responsible for the monitoring of marked animals, the estimated cost of the research effort would likely fall in the range of $20,000-25,000.

Management Procedures:

Herd Reduction
Currently it does not appear that herd reduction measures are warranted. In the event that the future necessitates such measures, they should be directed at the female herd segment. At least two options for active removals exist and installation managers should consider these in terms of efficacy, cost, and safety concerns. Early winter would be the best time to execute these removals when the animals are concentrated but still in good body condition. One would be to use military personnel (e.g. sharp-shooters) and donate the carcasses to charitable organizations. A second option would be a carefully controlled depredation hunt, but this would have to be proposed through the UDWR with the approval of the Wildlife Board.

Predator Management
Currently predation appears to be one of the factors that obviates the need for herd reduction measures. Moreover, the removal of livestock grazing from the installation eliminates justification of predator control from that standpoint. Accordingly, proactive predator control measures are not recommended at this juncture. However, certain circumstances may dictate the need for removal of specific animals. One scenario would be the situation in which an animal residing at CW makes regular forays into adjoining residential areas and poses a demonstrable threat to human safety. At that point, removal of the offending animal may be justified under the UDWR's Nuisance Cougar Policy. The eventuality of such a situation provides some justification for continued monitoring of cougars on the installation by means of radio-telemetry.

Reduction of Poaching
Contact was established with Ray Loken the Sergeant, who was going to confer with the CO's under his direction regarding possible means of reducing poaching incidents at CW. As of this date, I still have not heard back from him.

Fencing
Currently the installation is fenced from the Cantonment Area to Oak Springs, but this fence is permeable to deer, predators, and people. Although expensive, fencing may constitute one means of alleviating the negative interactions between deer and humans described above. However, complete fencing is not advisable because connectivity with the Oquirrh Mountains should be maintained.

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DEVELOPMENT OF A MULE DEER SAMPLING STRATEGY FOR ESTIMATION OF POPULATION SIZES

STUDY PROSPECTUS

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Conflict between sportsmen and wildlife agencies regarding the size, trend and appropriate management strategies for deer (*Odocoileus* spp.) parallels the history of the discipline (Leopold 1946, Diefenbach et al. 1997). The perennial problem of agency credibility with stakeholders was highlighted in a recent case history by Freddy et al. (2004) describing challenges surrounding estimation of mule deer numbers in Colorado. Using direct estimates from aerial quadrat counts, the authors contended that the Colorado Division of Wildlife (CDOW) successfully met the challenges, but cautioned other agencies in similar situations to use methods that can withstand public scrutiny. Rabe et al. (2002) surveyed the big-game survey methods used by the wildlife agencies in 12 western states. Currently only five states, namely Colorado, Idaho, Montana, New Mexico and Wyoming use aerial-based surveys to estimate mule deer numbers directly. Other states, including Utah, use some combination of herd composition counts, hunter-kill statistics and *post hoc* population models to obtain indirect indices of trend.

Reliable estimates of mule deer population size are important from two management perspectives: 1) assessing the effectiveness of population management via hunter-harvest manipulation (hunting regulations), and 2) evaluating the positive and negative impacts, respectively, of habitat improvement projects as well as potentially detrimental practices. Moreover, as population models are increasingly used to manage wildlife populations, more rigorous and objective methods should be used to provide input estimates (such as population size, survival rates, etc.) for these models so that they can withstand public scrutiny by an increasingly involved and diverse set of stakeholders (White and Lubow 2002).

The wildlife literature is replete with papers describing the estimation of abundance and related demographic parameters of free-ranging ungulates. Most researchers (and managers) agree that there exists a continuum with respect to the reliability of aerial survey techniques to enumerate ungulate populations, which is determined by several factors, including the animals'

relative size and social structure as well as the topographic relief and vegetative cover of the habitats they occupy (Pollock and Kendall 1987). Given these factors, techniques have been developed to achieve reliable estimates of mule deer population size from aerial counts. The approach, typically used for large scales, involves helicopter counts of animals on pre-determined quadrats based on a stratified random-sampling scheme (Thompson et al. 1998). In some instances the results are adjusted for visibility bias (Pollack and Kendall 1987, Samuel et al. 1987).

Utah Division of Wildlife Resources (UDWR) had been projecting the size of wintering populations of mule deer, and subsequently setting their harvest levels, using a computer model based on field-collected classification counts, harvest estimates based on hunter surveys, and survival rates estimated from studies in similar habitats and conditions (Unsworth et al. 1999). This approach is common in the intermountain west; however many state agencies supplement their models with field-based estimates to verify and validate the model estimates. Two main reasons make a strictly model-based approach undesirable; first, there is no way to evaluate how well the model works without some validation via field-based estimates, and second, lawsuits. Agencies are increasingly challenged in court by special interest groups on the scientific validity of their data and methods used make management decisions (Murphy and Noon 1991). To stand up to these rigors, population estimates should be direct rather than derived (Rabe et al. 2002).

Objectives

The first objectives of this prospectus are threefold. First we review field methods and monitoring designs used to estimate mule deer population size, second we discuss what should be monitored, and finally, we recommend the basis for a mule deer monitoring plan for UDWR.

Mule Deer Monitoring – What's Been Used?

There are 4 main field-based methodologies used to estimate population size for mule deer in intermountain west: 1) mark-resight, 2) distance sampling, 3) quadrat counts, and 4) quadrat counts adjusted for visibility bias.

In a mark-resight study, population size is estimated from an initial sample of mule deer that are captured and marked, with recaptures obtained by observing the deer, not by re-capturing them. Aerial mark-resight has been tested on known populations of mule deer (Bartmann et al. 1987) and white-tailed deer (Rice and Harder 1977). Aerial and ground based mark-resighting procedures have also been successfully used on other ungulate species including moose (Bowden and Kufeld 1995) and mountain sheep (Neal et al. 1993). However, the mark-resight procedure is more expensive, especially at a large-scale such as a wildlife management unit (WMU), and invasive than helicopter quadrat counts, due to the annual capture requirements for marking animals. In addition, the number of collared animals that are alive from the previous years collaring efforts needs to be determined (potentially with some supplemental radiocollars) at the start of each re-sighting effort. This method may be cost competitive in areas where deer have habituated to humans and can easily be captured and re-sighted.

Theoretically, line transects, or more specifically, distance sampling could be adapted for use on mule deer via aerial transects (Eberhardt l978, Buckland et al. 1993). Line transects

require minimal effort to establish and have been successfully employed on a relatively small scale (<47 km^2) to estimate mule deer population size using both driven transects (Koenen et al. 2002) and aerial transects (White et al. 1989). However, both these studies identified similar problems with the method; it is highly sensitive to violation of assumptions, and it requires an extremely strict protocol to meet its assumptions. By design, White et al. (1989) compared distance sampling to quadrat counts, and found distance estimates of population size to be slightly more economical and less biased than quadrat counts, for a given measure of precision. However, a "major problem with the use of distance sampling is the number of decisions that must be made to generate an estimate." (White et al. 1989). The "fussiness" of data collection protocols required to meet model assumptions, are generally not practical for wide scale use. We emailed White and asked which method he presently recommends, he answered "I tend to shy away from distance sampling because the attempts I was involved with for CDOW generally didn't work well unless the observers REALLY understood the theory behind the line transect method, and executed the surveys really well." (G. C. White, Colorado State University, personal communication). Thus, this method is probably not optimal for monitoring mule deer population abundance on large scale and has not been used for such in the western states

The most common method used for estimating mule deer population size is aerial quadrat counts (Gill 1969, Kufeld et al. 1980, Bartmann 1983, Bartmann et al. 1986). Also, quadrat counts corrected for visibility bias with a sightability factor have been used for mule deer (Unsworth et al. 1994) other large ungulates (Pollock and Kendall 1987, Samuel et al. 1987, Pojar et al. 1995, Anderson and Lindzey 1996, and Cogan and Diefenbach 1998). Factors commonly used to correct visibility bias include percent cover, habitat type, group size, group activity, weather conditions (including snow cover), and observer experience. Although no sightability factor was used for mule deer, Bartmann et al. (1986) noted that a 50% upward adjustment of the quadrat population estimate should provide a better estimate of true population size. In all these studies, either 2.59-km^2 or 0.64-km^2 quadrats were used depending on the amount of cover. After testing, Bartmann (1983) recommended 2.59-km^2 quadrats for pinyon-juniper woodlands to reduce the sampling variance; an adaptation of the 0.64-km^2 quadrats used in the more open sage-step habitats (Gill 1969, Kufeld et al. 1980).

The state-of-the-science of mule deer population size estimation methodology came in response to accusations from sportsman groups. Freddy et al. (2004) recount the challenging process of defending CDOW mule deer population size estimates in the face of a lawsuit by sportsmen groups, who alleged that CDOW was inflating the population size in order to keep license sales, and hence revenues, artificially high. In the area under question, CDOW had been using population models with only age and sex ratios input from field data; estimates from this approach would not stand up in court (Freddy et al. 2004). Hence, CDOW designed a quadrat-based sampling strategy to estimate mule deer population size in a data analysis unit (DAU) in northwest Colorado (due east of Vernal). Quadrat counts were conducted on 2.59-km^2 (for open sagebrush habitats) or 0.64-km2 areas (for pinion-juniper habitats) following recommendations of Kufeld et al. (1980), Bartmann (1983), and Bartmann et al. (1986), but corrected for visibility bias using Idaho Department of Fish and Game's mule deer sightability model (Unsworth et al. 1994). The study design and methodology of Freddy et al. (2004) stood up under intense public and scientific scrutiny. To directly estimate mule deer population size in Utah, we advocate adapting the strategy of Freddy et al. (2004).

Mule Deer Monitoring – What's Should Be Monitored?

The crucial field data required for a viable mule deer population model includes 4 main elements: total population size, recruitment rate of juveniles into the adult population, and juvenile and adult survival rates. In general, either a field-based estimate of population size or recruitement and survival are needed, although multiple sources of data provide the richest insight into the biological and management mechanisms of population fluctuation.

At the extreme, mule deer models that estimate population size are constructed using only field-based estimates of age and sex ratios, with other parameters estimated in an ad hoc and subjective fashion. These models lack any theoretical or empirical support, but are often used because herd composition data are easier to collect that are data required for direct population estimation (Bowden et al. 1984). In an attempt to construct a meaningful population model based on age and sex ratios, White et al. (1996) developed a method to estimate adult and juvenile over-winter survival based on age ratios of a population before and after winter, in conjunction with the age ratio of animals dying during the winter. However, they concluded that the assumptions of this method were unlikely to be met and the potential for bias considerable (White et al. 1996). The ultimate recommendation of White et al. (1996) was to use radio-telemetry data, rather than pre- and post-winter age ratios, to directly estimate survival rates.

In a continuation of this research vein, White and Bartmann (1998) suggest that "more effective monitoring can be accomplished by shifting resources from estimating recruitment to estimating over-winter survival in mule deer". They conclude that collecting age and sex ratios annually is wasteful because the variable being measured most often is likely the least important to measure on an annual basis (White and Bartmann 1998). Cost and effort associated with radiocollaring are the main reasons survival is not monitored more rigorously.

So, what should be monitored? In general, the 4 main elements required for a scientifically defensible model used to estimate population size should be monitored, at least on some sort of spatial and temporally rotating design. Resources should be allocated optimally to decide how many samples are needed to estimate population size, age and sex ratios, and adult and juvenile overwinter survival rates, with the ultimate goal of minimizing the variance of the population size and growth rate. Bowden et al. (2000) supply the methodology for optimally allocating resources to the 4 main samples needed to monitor a harvested mule deer population, predicated the assumption that only females are critical to the population dynamics. This method minimizes the variance of the estimated doe population size or doe population growth rate for a given budget. Because of the importance of this concept, we present an example of how it might work for a given population of interest in Utah. Note that costs are based on 1999 estimates and that additional cost savings could be realized by using drive counts for the age and sex ratio survey.

Given a mean annual budget of $50,000 is allocated to monitoring a mule deer population on a WMU for 5 years, and given annual costs for data collection are $150/population survey quadrat ($600/hr for helicopter time and 0.25 hour to count a quadrat), $150/age, sex-ratio survey quadrat ($600/hr for helicopter time and 0.25 hour to classify a quadrat),

$125/radiocollared doe ($225 for a radiocollar and $275 for capture prorated over 4 years), and $325/radiocollared fawn ($250 for a collar prorated over 5 years and $270 for capture each year), the optimal allocation for sample allocation would be 225 quadrats for population size, 20 quadrats for age and sex ratios, 68 radiocollars for doe survival estimates, and 15 radiocollars for fawn survival estimates. This would produce a reasonable CV for doe population size of 11.7%.

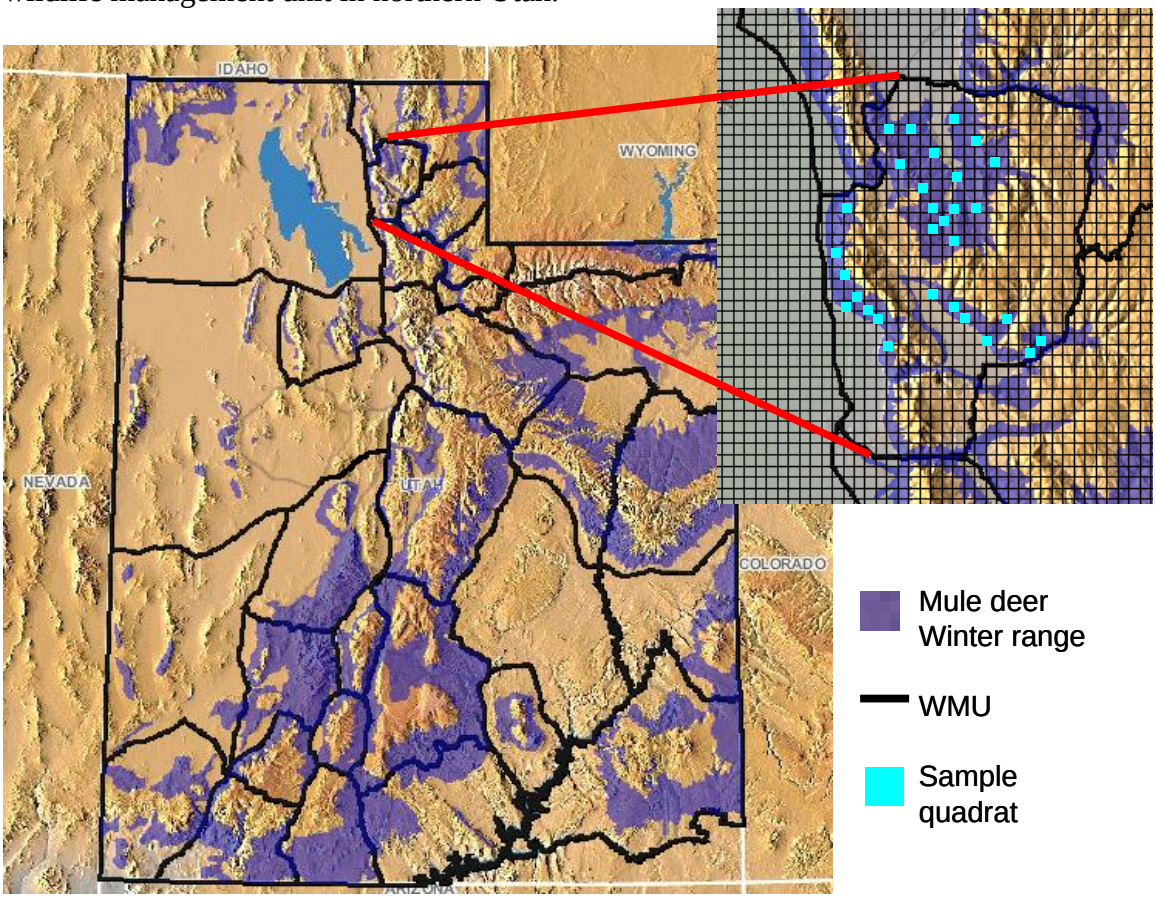
Mule Deer Monitoring – What Should Utah Use?

We recommend that UDWR base its monitoring plan on 2 crucial philosophical goals (following White and Bartmann 1998). First, UDWR mule deer management decisions must be based on data, and second, good data on a few mule deer population are better than poor data on all populations in Utah. With these overarching goals in mind, and knowing cost is prohibitive for monitoring across the large scale of Utah in its entirety, we begin with a few recommendations for a statewide mule deer monitoring plan:

1. Choose 3–5 mule deer populations/WMUs from the major ecoregions of Utah to monitor intensively. These populations should be representative of relevant herd characteristics and management, and environmental conditions. A cluster anlaysis could be used to chose monitoring area/populations based on as suite of relative factors within an ecoregion such as winter range habitat, harvest rate, recruitement rate, winter severity, etc.
2. To increase inference, design a random/rotating sampling scheme for other populations (in accordance with the annual budget) to monitor along with the chosen populations. Evaluate correlations between vital rates in core and non-core populations should be done to determine whether core units can be used to infer to and manage non-core units.
3. At a population scale, use Bowden et al. (2000) methodology to optimally allocate sampling effort to estimate population size, age and sex ratios, and adult and juvenile survival rates, in accordance with an annual budget.
4. Use aerial quadrat counts (sightability factor to be decided) be used to estimate population size, aerial or drive counts to estimate age and sex ratios, and radiotelemetry to estimate adult and juvenile survival rates.
5. A stratified random sample following the methodology of Freddy et al. (2004) should be used to choose quadrat sample units.
6. Estimate population size, via quadrat counts, only every 3-5 years, even in core areas.
7. Focus data collection and modeling efforts on females.
8. Because of its greatly reduced coefficient of variation, and hence increase “power” to detect change or effect of a management action, model population growth rate (λ) rather than population size for most years and most populations.
9. Adaptively check, change, and check again the performance of the monitoring plan.
10. Let us reiterate - less rather than more! Do a good job an fewer areas rather than a poor job on more areas (poor job not reflection of work effort, but rather due to dilution of resources so that inadequate data is collected to viably model population dynamics).

While this is not a detailed or comprehensive roadmap to the design of a statewide mule deer monitoring plan, it is a list of its sine qua nons. From here, a detailed sampling design can be developed based on factor such as mule deer winter range, habitat, management goals, budget constraints, and a statistically valid sampling scheme (e.g., Fig. 1).

Figure . Example of 2.59 km^2 grid based system for randomly choosing sample quadrats for a wildlife management unit in northern Utah.



The opportunity to start with a clean slate, working from the research knowledge gained from Idaho and Colorado, provides UDWR an almost unparalleled opportunity to design a credible, robust, and state-of-the science mule deer monitoring plan.

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