IDAHO DEPARTMENT OF FISH AND GAME

Steven M. Huffaker, Director

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Subproject 35

Completion Report

MULE DEER ECOLOGY

Study I: Winter Fawn Survival

Study II: Mule Deer Database

July 1, 2005 to June 30, 2006

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TABLE OF CONTENTS

LIST OF TABLES

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

COMPLETION REPORT
STATEWIDE WILDLIFE RESEARCH

STATE:	Idaho	**JOB TITLE:**	Mule Deer Ecology
PROJECT:	W-160-R-33		
SUBPROJECT:	35	**STUDY NAME:**	Winter Fawn Survival
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WINTER FAWN SURVIVAL

Abstract

Mule deer fawns were captured and radio-collared on 10 study areas across central and southern Idaho during December 2005 - January 2006 (n = 246). During winters 1998-1999 through 2005-2006, 5 study areas were monitored all 8 winters. The overall fawn survival rate during winter 2005-2006 was 0.31 (SE = 0.030), the lowest yet recorded. The 7 previous over-winter survival rates varied from 0.40 (SE = 0.031) in 2001-2002 to 0.76 (SE = 0.028) in 2004-2005. No difference in survival was observed between sexes (χ^2 = 0.184, df = 1, P > 0.668), but survival was significantly different between study areas (χ^2 = 45.00, df = 9, P < 0.0001). Total predator losses varied from 7-28% of fawns each winter. Verified coyote predation accounted for 2-14% of fawns, mountain lions took 3-12%, and other predators (bobcat, dog, wolf, unknown predator) 1-4%. An additional 3-37% died from malnutrition, and 4-12% of fawns died of other causes (reservoirs, road-kills, trains, unknown). Fawn size and condition was assessed at the time of capture by measuring mass (kg), chest girth (cm), and hind foot length (cm). Pooled data from all 8 winters, 1998-2006, (n = 1,657) indicated that fawns surviving the winter were heavier than fawns that died (F = 104.41, df = 1, P < 0.0001), male fawns were larger than female fawns (F = 182.10, df = 1, P < 0.0001), fawn mass varied among the study areas (F = 12.25, df = 22, P < 0.0001), and fawns were heavier in 1998-1999 than in any subsequent winter (F = 10.19, df = 7, P < 0.0001). The simplest model which effectively explained fawn survival (χ^2 = 366.95, df = 63, P < 0.0001) included sex, mass, study area, winter, and a study area*winter interaction term.

Mule deer (*Odocoileus hemionus*) are affected by a variety of factors that cause populations to fluctuate widely. Weather variables cause the most dramatic year-to-year variation in survival and recruitment while habitat changes probably have the greatest long-term impact. Unaltered habitat types may also vary in quality annually in response to ungulate and livestock densities and weather. Predation is a common mortality cause, but often compensates for other forms of mortality. Determining the extent to which predators may limit population growth is very difficult. Expanding predator populations coupled with declining deer populations have initiated heated debate among biologists and sportsmen as to the role of predators. Harassment, disease, and parasites can cause animals to be more susceptible to other forms of mortality. These numerous factors collectively have a much greater impact on mule deer populations than harvest.

The extent to which mule deer populations are influenced by hunting depends on season structure and timing as well as road densities and vehicle access. The myriad of factors that effect mule deer are complex, making the wildlife manager's job difficult.

A recent decline in mule deer populations across the West, with relatively low recruitment in following years, has caused concern among biologists and sportsmen alike (Unsworth et al. 1999). Severe weather during the 1992-1993 winter apparently spurred the decline by causing high mortality. Fawn survival ranged from 0-38% during that winter among 3 study areas in southwest Idaho. There is little consensus as to why populations have not recovered more rapidly, likely because many interacting factors affect mule deer populations. In many cases, wildlife managers cannot prevent high mortality and subsequent low recruitment. However, it is imperative that managers detect population changes when they occur. Disagreements between the Department and sportsmen could be alleviated with more communication and better information. Improved monitoring of populations will enable managers to make better decisions regarding harvest and allow hunters to be more informed.

Aside from hunting, the many variables influencing deer survival have the greatest impact on fawns. Fawns accumulate less fat reserves than adults during summer and fall, making them more susceptible to weather severity, poor quality habitat, predators, harassment, disease etc. This results in fawns having higher mortality rates than adult deer (Bartmann 1984, White et al. 1987, Pac et al. 1991, White and Bartmann 1998, Unsworth et al. 1999). Unsworth et al. (1999) found that annual variation in fawn survival could impact the annual rate of increase of mule deer populations. White and Bartmann (1998) and Unsworth et al. (1999) recommended that managers monitor over-winter fawn survival, adult doe survival, December age and sex ratios, and population size on an annual basis. The Department has traditionally monitored population size and age and sex ratios on a statewide level, but not survival rates. Adult doe survival is much less variable from year to year than fawn survival (Unsworth et al. 1999). Given the expense associated with estimating survival rates on a statewide basis, managers should focus efforts on survival of fawns rather than does. We, therefore, incorporated estimates of over-winter fawn survival into the Department's monitoring program, following the current Mule Deer Management Plan (IDFG 1998), to develop more accurate population models for management purposes.

Improved monitoring of mule deer will help managers meet specific goals of herd size and composition by altering doe harvests according to annual changes in survival, recruitment, and population size (Unsworth et al. 1999). White and Bartmann (1998) developed a model based on over-winter fawn survival, annual doe survival, and December fawn:doe ratios to calculate a population's annual rate of increase, λ. In recent years throughout southwest Idaho, over-winter fawn survival has ranged from 0.22 to 0.76, while December fawn:doe ratios have ranged from 49-77:100 (Unsworth et al. 1999). By collecting these data annually, managers can determine whether the population is decreasing, stable, or increasing. In years where low December fawn:doe ratios are coupled with high winter fawn mortality, poor yearling recruitment could initiate a decline. Restrictive doe harvests would improve the likelihood or rate of population recovery. Based on long-term averages of over-winter fawn survival (0.444) and annual adult female survival (0.853) in Colorado, Idaho, and Montana, Unsworth et al. (1999) estimated that 0.662 fawns:doe (in December) was necessary to maintain populations.

Another difficulty for wildlife managers is that much of the deer monitoring data is collected after harvest regulations have been determined for the following hunting season. Managers submit big game season recommendations for the upcoming year by early January, and final harvest regulations are adopted by the Commission in March (B. Compton, IDFG, personal communication). Department recommendations are based primarily on harvest surveys and population information. When capturing and radio-collaring fawns to monitor survival, the mass of each animal can be measured with relative ease. Early winter mass can be used to predict over-winter fawn survival (Bishop 1998, Unsworth et al. 1999). After several years of obtaining baseline data, managers should be able to predict winters in which mortality rates will be large. Managers can then make more informed decisions regarding doe harvests by comparing December fawn:doe ratios with a prediction of upcoming winter fawn survival.

Study Area

Six winter range trend areas plus the 2 study areas in the southeast Idaho mule deer study were selected as permanent study areas across central and southern Idaho in the Southwest, Magic Valley, Southeast, Upper Snake, and Salmon regions (Table 1; Figure 1). The McCall study area (44°06’, 116°30’) is located in Game Management Units (GMUs) 32 and 32A north of Emmett. Terrain comprises rolling foothills and benches; elevations range from 2,500-5,000 feet. Vegetation is dominated by sagebrush (*Artemisia* spp.) and grassland habitat types with occasional agricultural lands on the southern border. Willow (*Salix* spp.) and aspen (*Populus tremuloides*) occur in some drainage bottoms. The Boise study area (43°35’, 116°02’) is located in GMU 39 on the Boise River Wildlife Management Area (WMA) to the northwest of Lucky Peak Reservoir. Terrain consists of relatively steep canyon breaks and elevations range from 3,100 feet at Lucky Peak Reservoir to 5,200 feet near Lucky Peak. Vegetation comprises sagebrush-grass habitat types, and a portion of the area burned in 1992 and 2000. The Twin Falls study area (42°21’, 114°21’) is located in GMU 54 in the South Hills. Terrain comprises rolling hills dissected by several major drainages with elevations ranging from 4,150-5,900 feet. Vegetation is composed of sagebrush-grass habitat types with scattered pockets of bitterbrush (*Purshia tridentata*). The Pocatello study area (42°43’, 111°43’) is located in GMU 72 in the Soda Hills. Terrain consists of rolling hills and open valleys; elevations range from 5,800-6,800 feet. Vegetation consists of sagebrush-grass habitat types at lower elevations with juniper (*Juniperus* spp.) and mountain mahogany (*Cercocarpus* spp.) habitats above; aspen and Douglas-fir (*Pseudotsuga menziesii*) sites occur on north slopes and high ridges. The Idaho Falls study area (43°40’, 111°25’) is located in GMU 67 near the South Fork of Snake River. Terrain is moderate to steep with elevations from 5,000-6,700 feet. Vegetation is dominated by sagebrush and mountain shrub with some juniper habitat types. The Challis study area (44°26’, 114°15’) is located in GMU 36B around Centennial Flat. Terrain comprises rolling foothills cut by small drainages with steep mountain slopes above; elevations range from 5,200-8,300 feet. Vegetation consists of sagebrush-grass habitat types and occasional mountain mahogany with conifer patches at higher elevations. GMUs 56 and 73A are the 2 study areas in the southeast Idaho mule deer research project; refer to Hurley and Unsworth (1999) for study area descriptions. These 2 areas are referred to as the SE Idaho research areas. In addition to the permanent study areas, other sites in various areas have been investigated for 1 or more winters. Fawns were monitored in GMUs 21A, 22, 28, 30, 31, 33, 50, 58, 60A, 67, 69, 73, and 76 in addition to the permanent study areas.

Job 1. Over-winter Survival Rates and Cause-specific Mortality of Mule Deer Fawns

Objectives

Our goal is to evaluate over-winter fawn survival and cause-specific mortality as part of an ongoing management program to monitor mule deer populations in Idaho (IDFG 1998). Our specific objectives are to determine whether: 1) over-winter fawn survival rates differ between sexes, years, or among study areas; 2) the probability that mortality is related to early winter mass, chest girth, or hind foot length of fawns; and 3) different mortality causes occur in equal frequency among study areas, sexes, or years. Within the framework of these objectives, we developed 2 specific a priori null hypotheses: 1) early winter mass, chest girth, and hind foot length of fawns in southeast Idaho do not differ from fawns in other regions; and 2) over-winter survival rates of fawns in southeast Idaho do not differ from fawns in other regions. Since the widespread deer decline in 1992-1993, populations in southeast Idaho have recovered more slowly than populations in the central and western portions of the state, yet habitat quality in southeast Idaho appears to be quite good. This report contains methods and results from the first 5 years of monitoring and addresses our objectives and hypotheses in a preliminary manner.

Methods

<u>Capture and Radio-collaring Fawns</u>

From 185 to 253 mule deer fawns were captured and radio-collared each winter (Table 2). Helicopter drive-nets (Beasom et al. 1980) were generally used to capture the fawns but occasionally fawns were also net-gunned from a helicopter (Barrett et al. 1982, Van Reenen 1982) and clover-trapped. Drive-netting enabled volunteers from the public to assist in capture efforts which was a goal of the project. Nine to 34 fawns were captured, radio-collared, fitted with plastic ear tags, and measured in each fawn monitoring study area. Two types of radio-collars were used: expandable collars and belt collars. All collars were equipped with mortality sensors and fastened with temporary attachment plates or surgical tubing, causing the collars to fall off the animals after approximately 6-8 months. We retrieved the shed collars for use on next year’s fawns. Fawn weight (kg), chest girth (cm), and hind foot length (cm) were measured to assess early winter body size and condition. Adult does captured opportunistically with drive-nets were ear-tagged, aged, measured, and some were bled for pregnancy testing and nutritional analysis (Table 3).

<u>Mortality Monitoring and Determining Cause of Death</u>

Fawn radio signals were monitored for mortality from the ground approximately every other day throughout winter. Relocations of live fawns were not obtained. Aerial monitoring was used on occasion if radio signals could not be detected from the ground. When a mortality signal was detected, the fawn was located and cause of death was determined using the following protocol:

1. Site evaluation – tracks, scat, broken vegetation, blood, drag trails, etc.
2. Collar assessment – condition, mortality or live signal, location.
3. Carcass description – intactness, relative position of body parts, missing body parts.
4. External necropsy – abnormalities, wounds, canine punctures, degree of consumption, chewed or fragmented bones, etc.
5. Internal necropsy – hemorrhaging, bruises, canine punctures, abnormalities, fat deposits, broken bones, etc.
6. Femur marrow fat – white, hard, and waxy; pink to red and firm; red to pink and soft; deep red and gelatinous.

The latitude and longitude in decimal minutes, or Universal Transverse Mercator (UTM) coordinates were recorded at each mortality location. All latitude and longitude coordinates were converted to UTM coordinates. A point coverage will be created in ARC/INFO® (ESRI 1995, 1997) using all mortality locations.

Statistical Methods

Over-winter fawn survival curves and rates (Dec-May) were estimated using the staggered entry Kaplan-Meier procedure (Kaplan and Meier 1958, Pollock et al. 1989). A chi-square analysis (Program CONTRAST: Sauer and Williams 1989) was used to compare survival rates and the log-rank test (Cox and Oakes 1984, Pollock et al. 1989) to compare survival functions among sexes, study areas, and years. We used Program CONTRAST (Sauer and Williams 1989) to test our a priori null hypothesis that fawn survival rates were not different between southeast Idaho study areas (GMUs 67, 69, 73A, 72) and all others (GMUs 32, 36B, 39, 54). Fawns dying within 7 days of capture were excluded from all analyses to prevent any capture-related mortalities from influencing the sample. Fawns that shed their collars prior to the ending date of the study were right-censored (Kaplan and Meier 1958, Kalbfleisch and Prentice 1980, Cox and Oakes 1984, Pollock et al. 1989) at the estimated date of collar loss. Winter fawn survival was modeled as a function of sex, study area, capture mass, chest girth, and hind foot length with a logistic regression using JMP statistics package.

Using JMP, a multiple analysis of variance (MANOVA) type linear model was used to test for differences in early winter mass, chest girth, and hind foot length of fawns between sexes, study areas, fates (i.e., lived or died), and years.

Results and Discussion

Survival

Mule deer fawns were captured and radio-collared on 10 study areas (Table 2) across central and southern Idaho during December 2005 - January 2006 (n = 246). Five fawns died within 7 days of capture and were removed from the data set. An additional 3 animals were never located after marking; thus, 238 fawns were used in analyses. During winters 1998-1999 through 2005-2006, 5 study areas were monitored all 8 winters. The overall fawn survival rate during winter 2005-2006 was 0.31 (SE = 0.030), the lowest yet recorded (Table 4). The 7 previous over-winter survival rates varied from 0.40 (SE = 0.031) in 2001-2002 to 0.76 (SE = 0.028) in 2004-2005. No difference in survival was observed between sexes ($\chi^2 = 0.184$, df = 1, $P > 0.668$), but survival was significantly different between study areas ($\chi^2 = 45.00$, df = 9, $P < 0.0001$).

Including fawns from 9 study areas monitored at least 4 of 8 field seasons ($n = 1{,}378$), the simplest model which effectively explained fawn survival ($\chi^2 = 366.9$, df = 63, $P < 0.0001$) included sex, mass, and winter both as a main effect and as an interaction effect with study areas (Table 5). Specific mortality-cause models were similar to the whole model.

Cause-specific Mortality

Total predator losses varied from 7-28% of fawns each winter (Table 6). Verified coyote predation accounted for 2-14% of fawns, mountain lions took 3-12%, and other predators (bobcat, eagle, dog, wolf, unknown predator) 1-4%. An additional 3-37% died from malnutrition, and 4-12% of fawns died of other causes (reservoirs, road-kills, trains, unknown). In 2005-2006, winter malnutrition was the highest verified mortality cause, the highest loss rate of any winter, and accounted for 36.6% of fawn deaths.

Fawn Mass, Chest Girth, and Hind Foot Length

2005-2006 male fawns were heavier than female fawns ($F = 24.66$, df = 1, $P < 0.0001$), had longer hind feet ($F = 38.28$, df = 1, $P < 0.0001$), and had larger chest girths ($F = 7.18$, df = 1, $P > 0.0079$). Fawn mass ($F = 7.59$, df = 9, $P < 0.0001$), hind foot length ($F = 6.83$, df = 9, $P < 0.0001$), and chest girth ($F = 2.52$, df = 9, $P > 0.0090$) varied among the 10 study areas (Tables 7-9). Overall, 1998-1999 fawns were heavier than any subsequent year ($F = 10.19$, df = 7, $P < 0.0001$). 2004-2005 fawns were lighter than 1998-1999 fawns but heavier than any other remaining year. 1998-1999 hind foot lengths ($F = 2.13$, df = 7, $P > 0.0376$), and chest girths ($F = 10.44$, df = 7, $P < 0.0001$) were not different from 2004-2005 but were significantly larger than any other year.

Pooled data from 8 winters, 1998-2006 ($n = 1{,}657$) indicate that, in general, fawns surviving the winter were larger than fawns that died. Surviving fawns weighed more ($F = 104.41$, df = 1, $P < 0.0001$), had longer hind feet ($F = 54.88$, df = 1, $P < 0.0001$), and larger chest girths ($F = 61.13$, df = 1, $P < 0.0001$) than fawns that died.

Fawn mass is correlated with hind foot length ($r^2 = 0.46$, $F = 1489$, $P < 0.0001$) and chest girth ($r^2 = 0.33$, $F = 868$, $P < 0.0001$). Chest girth is weakly associated with hind foot length ($r^2 = 0.17$, $F = 353$, $P < 0.0001$). The linear regression fit of weight to hind foot length and chest girth is significant (weight = -48.30 + 1.38 hind foot + 0.32 chest girth, $r^2 = 0.57$, $F = 1154$, df = 2, $P < 0.0001$). Although the sex of the fawn is a statistically significant addition to the model, it does not constitute an important contribution to model fit; $r^2 = 0.572$ compared to $r^2 = 0.557$ without sex in the model.

Job 2. Annual Rate of Increase (Net Recruitment) of Mule Deer Populations

Objective

Our objective is to estimate the annual rate of increase, or net recruitment, of the mule deer population in each fawn monitoring study area in central and south Idaho.

Methods

Over-winter fawn survival, December fawn:doe ratios, and mean annual adult female survival are necessary to estimate a population's annual rate of increase. Estimates of over-winter fawn survival were obtained in Job 1. December fawn:doe ratios will be estimated annually with herd composition surveys conducted during late December and early January using a helicopter. Areas surveyed will include the study areas in which over-winter fawn survival is monitored. Protocol for herd composition surveys will follow standard Department procedures already in place. Survival of adult female deer varies little from year to year in terms of natural mortality (Unsworth et al. 1999). Unsworth et al. (1999) estimated that adult doe survival will be <0.8 only 7% of the time, and mean annual doe survival in Colorado, Idaho, and Montana was 0.853. Prior mean estimates of annual doe survival will be used for each study area (trend population) in this analysis. Harvest surveys will be used to estimate hunter-caused mortality for areas with doe harvests, and mean annual survival estimates will be adjusted accordingly.

A Leslie matrix model (Leslie 1945, 1948; Lefkovitch 1965) will be used to estimate population annual rate of increase or net recruitment. Assuming a 2 age-class model (fawns/adults), White and Bartmann (1998) defined the annual rate of increase (N_{t+1}/N_t) as

$$\lambda = \frac{RS_F + 2S_A}{2},$$

where R is the December fawn:doe ratio, S_F is the over-winter fawn survival rate, and S_A is the mean annual adult female survival rate. This model will be used to determine whether a population is decreasing, static, or increasing.

Results and Discussion

No progress.

Table 1. Winter range study areas for monitoring mule deer fawn mortality, 1998-2006.

Region	Study area reference name	GMU(s)	Study area location
Southwest	Hells Canyon	22/31	Brownlee and Oxbow Reservoirs
	Dodson Pass	32A	Dodson Pass
	Sulphur Gulch	32	Sulphur Gulch
	Boise	39	Boise River WMA
	Garden Valley	33	Garden Valley
Magic Valley	Twin Falls	54	South Hills
	SE ID Research	56	Most of GMU 56
Southeast	SE ID Research	73A	Most of GMU 73A
	Pocatello	72	Soda Hills
	Elkhorn	73	Elkhorn Mountain
	Bear Lake	76	Northeast of Bear Lake
Upper Snake	Idaho Falls	67	Table Rock / Heise Hot Springs
	Medicine Lodge	59A	Medicine Lodge
	Marsh Canyon	50	Marsh Canyon
	Wolverine Canyon	69	Wolverine Canyon
	Tex Creek	69	Tex Creek WMA
	Sand Creek WMA	60A	Sand Creek WMA
	Birch Creek	58	East side of Birch Creek
Salmon	Tower Creek	21A	Tower Creek – 4th of July Creek
	Salmon	28	Smedley
	Salmon	30	Warm Springs and Reese Creek
	Challis	36B	Centennial Flat

Table 2. Results of mule deer fawn capture using helicopter drive nets and net guns in central and south Idaho, December and January, 1998-2006.

		Number of fawns[a]							
Study area	GMU(s)	1998 -1999	1999 -2000	2000 -2001	2001 -2002	2002 -2003	2003 -2004	2004 -2005	2005 -2006
Hells Canyon	22/31	24	20	20	14		25		
Dodson Pass	32A			21					
Sulphur Gulch	32				25	25	25	25	25
Boise	39	20	20	20	25	26	25	25	25
Garden Valley	33							25	24
Twin Falls	54	26	17	24	24	25	26	26	25
SE ID Research	56	29	30	30	30				
SE ID Research	73A	34	29	25	30	9	26		
Pocatello	72	26	20	25	25	25	25	26	24
Elkhorn	73							28	
Bear Lake	76								25
Idaho Falls	67	22	25	20	26	25	26	25	25
Medicine Lodge	59A			16					
Marsh Canyon	50				24				
Wolverine Canyon	69					26			
Tex Creek WMA	69								25
Sand Creek WMA	60A						26		
Birch Creek	58							20	
Tower Creek	21A								24
Salmon	28	21							
Salmon	30		21				23	25	
Challis	36B	24	32	26	27	24	26	21	24
Total		226	214	227	250	185	253	246	246

[a] Fawns were radio-collared, ear-tagged, weighed, and measured for chest girth and hind foot length. Approximately 10 fawns from each area were bled for nutritional analysis in 1999-2000 and 2000-2001.

Table 3. Results of mule deer doe and buck capture using helicopter drive nets and net guns in central and south Idaho, December and January, 1998-2005.

		Year/Number of does[a,b]								Year/Number of bucks[b,c]							
Study area	GMU	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06	98-99	99-00	00-01	01-02	02-03	03-04	04-05	05-06
Hells Canyon	22/31	0	0	0	0		0			0	0	0	0		0		
Dodson Pass	32A			7								0					
Sulphur Gulch	32				8	9	21	3	7				0	2	0	0	0
Boise	39	14	11	3	6	12	18	0	16	1	0	2	1	1	1	0	0
Garden Valley	33							2								0	
Twin Falls	54	25	19	8	12	9	4	0		9	0	3	2	3	2	0	
SE ID Research	56	15	18	19	4					0	1	0	0				
SE ID Research	73A	22	24	14	6	7	13			3	0	0	0	0	0		
Pocatello	72	16	14	9	0	12	12	0	1	0	0	0	0	0	0	0	0
Elkhorn	73							0								0	
Bear Lake																	
Idaho Falls	67	15	20	5	7	8	8	5		1	1	0	0	0	1	1	
Medicine Lodge	59A			3								0					
Marsh Canyon	50				17								1				
Wolverine Canyon	69					24								1			
Tex Creek WMA																	0
Sand Creek WMA	60A						17								0		
Birch Creek	58							12								0	
Tower Creek									14								1
Salmon	28	9								0							
Salmon	30		12				10	5			2				1	0	
Challis	36B	10	14	5	6	9	4	0	4	1	0	4	0	0	1	0	0
Total		126	132	73	66	90	81	27	42	15	4	9	4	7	6	1	1

[a] Does were ear-tagged, measured for chest girth and hind foot length, and bled for pregnancy testing and nutritional analysis.
[b] Number of does and bucks captured in 2001-2005 are minimums because some adult deer were released without processing.
[c] Bucks in Twin Falls (GMU 54) were radio-collared and ear-tagged in 1998-1999, 2000-2001, 2001-2002, and 2002-2003.

Table 4. Winter survival rates and standard errors (SE) of radio-collared mule deer fawns in central and south Idaho.

Category	Survival rate (SE)[a]							
Group	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006
Dates	12/17 - 5/31	12/13 - 5/12	12/15 - 5/15	12/12 - 5/15	12/18 - 5/15	12/16 - 5/15	12/11-5/15	12/15-5/15
Number of fawns	223	208	225	243	185	253	243	246
Sex								
Females	0.65 (0.055)	0.57 (0.052)	0.70 (0.043)	0.42 (0.044)	0.70 (0.051)	0.54 (0.046)	0.78 (0.036)	0.30 (0.041)
Males	0.64 (0.050)	0.56 (0.049)	0.72 (0.046)	0.39 (0.045)	0.68 (0.048)	0.54 (0.044)	0.74 (0.042)	0.33 (0.044)
Overall	0.64 (0.037)	0.57 (0.036)	0.71 (0.031)	0.40 (0.031)	0.69 (0.035)	0.54 (0.032)	0.76 (0.028)	0.31 (0.030)
Study areas								
Hells Canyon-22/31	0.52 (0.109)	0.35 (0.107)	0.53 (0.121)	0.08 (0.080)				
Dodson Pass-32A			0.53 (0.138)					
Sulphur Gulch-32				0.68 (0.093)	0.64 (0.103)	0.32 (0.093)	0.88 (0.065)	0.44 (0.103)
Boise-39	0.88 (0.126)	0.85 (0.082)	0.90 (0.067)	0.48 (0.100)	0.57 (0.100)	0.38 (0.098)	0.76 (0.085)	0.59 (0.100)
Garden Valley-33							0.92 (0.054)	0.04 (0.042)
Twin Falls-54	0.75 (0.141)	0.59 (0.134)	0.63 (0.099)	0.59 (0.105)	0.80 (0.089)	0.85 (0.071)	0.73 (0.087)	0.45 (0.106)
SE ID Research-56	0.71 (0.083)	0.54 (0.095)	0.76 (0.081)	0.30 (0.084)				
SE ID Research-73A	0.73 (0.076)	0.86 (0.064)	0.76 (0.085)	0.26 (0.080)	0.89(0.105)	0.50 (0.098)		
Pocatello-72	0.60 (0.115)	0.79 (0.096)	0.75 (0.088)	0.08 (0.056)	0.76 (0.085)	0.56 (0.099)	0.56 (0.099)	0.10 (0.064)
Elkhorn-73							0.73 (0.087)	
Bear Lake-76								0.62 (0.099)
Idaho Falls-67	0.62 (0.121)	0.62 (0.115)	0.74 (0.114)	0.36 (0.096)	0.92 (0.054)	0.54 (0.098)	0.68 (0.093)	0.16 (0.073)
Medicine Lodge-59A			0.81 (0.098)					
Marsh Canyon-50				0.38 (0.105)				
Wolverine Canyon-69					0.73 (0.087)			
Tex Creek WMA-69								0.24 (0.085)
Sand Creek WMA						0.84 (0.073)		
Birch Creek-58							0.80 (0.089)	
Tower Creek-21A								0.17 (0.076)
Salmon-28	0.62 (0.128)							
Salmon-30		0.32 (0.188)				0.57 (0.103)	0.96 (0.039)	
Challis-36B	0.36 (0.110)	0.36 (0.092)	0.77 (0.085)	0.77 (0.083)	0.39 (0.102)	0.34 (0.096)	0.62 (0.106)	0.26 (0.092)

[a] Survival rates and SEs were calculated following Pollock et al. (1989).

Table 5. Logistic regression survival results from radio-collared mule deer fawns (n = 1,378) monitored at least 4 of 8 winters in 9 study areas, 1998-1999 through 2005-2006.

Variable	Likelihood ratio chi-square probability values				
	All sources mortality model	Malnutrition mortality model	Coyote mortality model	Mountain lion mortality model	All predation mortality model
Individual effect tests					
Weight	0.000	0.002	0.000	0.000	0.000
Sex	0.618	0.908	0.050	0.462	0.495
Study area	0.000	0.000	0.016	0.002	0.005
Winter	0.000	0.000	0.000	0.000	0.000
Study area*winter interaction	0.001	0.000	0.000	0.000	0.000
Whole model tests					
Model chi-square (df = 62)	0.000	0.000	0.000	0.000	0.000
Lack of fit chi-square	0.001	1.000	1.000	1.000	0.352
R^2	0.20	0.36	0.22	0.25	0.20

Table 6. Over-winter fates of radio-collared mule deer fawns in central and south Idaho.

	Number of fawns							
Fate	1998 -1999	1999 -2000	2000 -2001	2001 -2002	2002 -2003	2003 -2004	2004 -2005	2005 -2006
Possible capture-related mortality[a]	3	5	2	8	1	1	4	5
Collars shed or lost prior to May	46	24	10	2	2	7	1	6
Collars retained to May	107	108	150	99	127	129	188	72
Coyote predation	22	25	25	28	25	33	5	36
Mountain lion predation	15	15	10	29	11	16	8	9
Other predation	5	3	4	10	1	10	4	6
Malnutrition	19	16	6	45	5	25	18	85
Other[b]	9	17	20	29	13	19	22	27
Total	226	213	227	250	185	253	246	246

[a] Mortality occurred within 7 days of capture. In 2001-2002 it includes 1 fawn that had the magnet left on the collar.
[b] "Other" mortality causes include automobiles, trains, fences, hay bloat, and unknown causes of mortality.

Table 7. Mean mass (SE) in kg of radio-collared mule deer fawns in central and south Idaho.

Category Group	Dec 1998- Jan 1999	Dec 1999- Jan 2000	Dec 2000- Jan 2001	Dec 2001- Jan 2002	Dec 2002- Jan 2003	Dec 2003- Jan 2004	Dec 2004- Jan 2005	Dec 2005- Jan 2006
Overall								
All fawns	37.4 (0.33)	34.8 (0.32)	34.5 (0.31)	34.6 (0.27)	35.2 (0.35)	34.9 (0.27)	36.5 (0.27)	35.2 (0.32)
Fate								
Lived	38.0 (0.39)	35.6 (0.39)	35.1 (0.35)	35.4 (0.39)	36.5 (0.38)	35.8 (0.34)	36.7 (0.30)	37.0 (0.55)
Died	36.0 (0.57)	33.3 (0.53)	32.7 (0.59)	34.0 (0.36)	32.1 (0.58)	33.7 (0.40)	35.5 (0.56)	34.5 (0.39)
Sex								
Males	39.0 (0.44)	35.9 (0.42)	36.0 (0.43)	35.9 (0.40)	36.8 (0.46)	36.1 (0.36)	37.9 (0.43)	36.8 (0.46)
Females	35.8 (0.44)	33.6 (0.46)	33.1 (0.40)	33.5 (0.32)	33.3 (0.45)	33.4 (0.36)	35.2 (0.30)	33.7 (0.42)
Study areas								
Hells Canyon-22/31	38.3 (1.01)	35.1 (0.98)	36.4 (1.07)	34.4 (0.88)		34.3 (0.82)		
Dodson Pass-32A			35.7 (0.96)					
Sulphur Gulch-32				35.1 (0.98)	35.0 (1.03)	33.7 (0.73)	37.7 (1.03)	36.5 (0.79)
Boise-39	35.6 (1.01)	36.0 (0.93)	34.0 (0.99)	36.1 (0.62)	33.0 (0.82)	34.4 (0.86)	37.0 (0.81)	36.9 (0.78)
Garden Valley-33							36.2 (0.60)	31.8 (0.85)
Twin Falls-54	35.4 (0.88)	32.5 (1.01)	32.3 (0.92)	35.8 (0.70)	33.2 (0.83)	35.6 (0.80)	34.7 (0.64)	33.3 (1.15)
SE ID Research-56	38.8 (0.87)	35.5 (0.76)	34.2 (0.82)	36.8 (0.79)				
SE ID Research-73A	37.3 (0.80)	36.9 (0.78)	35.9 (0.88)	33.5 (0.68)	35.1 (1.55)	35.2 (0.76)		
Pocatello-72	38.0 (0.92)	36.7 (0.95)	35.7 (0.92)	34.0 (0.81)	38.1 (0.84)	36.1 (0.82)	36.7 (0.95)	37.1 (0.94)
Elkhorn-73							34.4 (0.74)	
Bear Lake-76								34.3 (0.88)
Idaho Falls-67	41.2 (1.01)	37.6 (0.83)	36.0 (0.99)	36.3 (0.75)	38.5 (0.77)	39.5 (0.66)	39.1 (0.84)	36.2 (1.17)
Medicine Lodge-59A			32.5 (1.10)					
Marsh Canyon-50				30.5 (0.75)				
Wolverine Canyon-69					36.5 (0.86)			
Tex Creek WMA-69								39.9 (0.72)
Sand Creek-60A						35.1 (0.83)		
Birch Creek-58							35.2 (0.78)	
Tower Creek-21A								33.1 (0.67)
Salmon-28	37.7 (0.98)							
Salmon-30		31.5 (0.93)				32.2 (0.69)	38.7 (0.77)	
Challis-36B	34.7 (0.94)	31.6 (0.73)	32.2 (0.86)	33.2 (0.75)	31.9 (0.57)	32.2 (0.64)	34.5 (0.78)	32.7 (1.04)

Table 8. Mean hind foot length (SE) in cm of radio-collared mule deer fawns in central and south Idaho.

Category Group	Dec 1998- Jan 1999	Dec 1999- Jan 2000	Dec 2000- Jan 2001	Dec 2001- Jan 2002	Dec 2002- Jan 2003	Dec 2003- Jan 2004	Dec 2004- Jan 2005	Dec 2005- Jan 2006
Overall								
All fawns	43.1 (0.14)	42.7 (0.14)	42.6 (0.12)	42.7 (0.11)	42.7 (0.12)	42.7 (0.10)	43.0 (0.16)	42.6 (0.12)
Fate								
Lived	43.4 (0.16)	43.0 (0.16)	42.7 (0.14)	43.0 (0.15)	42.9 (0.13)	42.9 (0.12)	43.1 (0.20)	43.1 (0.21)
Died	42.5 (0.26)	41.8 (0.23)	42.2 (0.22)	42.5 (0.16)	42.2 (0.22)	42.5 (0.16)	42.7 (0.20)	42.4 (0.14)
Sex								
Males	43.6 (0.19)	43.1 (0.19)	43.2 (0.16)	43.2 (0.16)	43.3 (0.14)	43.1 (0.14)	43.7 (0.31)	43.3 (0.16)
Females	42.6 (0.19)	42.1 (0.19)	42.0 (0.15)	42.3 (0.15)	42.0 (0.16)	42.3 (0.14)	42.3 (0.13)	41.9 (0.15)
Study areas								
Hells Canyon-22/31			42.6 (0.38)	42.6 (0.76)		43.1 (0.24)		
Dodson Pass-32A			42.5 (0.37)					
Sulphur Gulch-32				43.2 (0.44)	43.9 (0.35)	43.0 (0.21)	43.6 (0.40)	43.4 (0.30)
Boise-39	42.6 (0.44)	42.9 (0.39)	43.0 (0.38)	43.3 (0.31)	42.6 (0.28)	43.5 (0.37)	43.6 (0.31)	43.3 (0.26)
Garden Valley-33							42.5 (0.27)	42.1 (0.26)
Twin Falls-54	42.9 (0.37)	42.2 (0.42)	41.8 (0.35)	42.8 (0.32)	42.1 (0.31)	43.0 (0.32)	42.4 (0.32)	42.2 (0.37)
SE ID Research-56	43.9 (0.35)	43.3 (0.32)	42.6 (0.31)	43.3 (0.27)				
SE ID Research-73A	43.0 (0.32)	43.5 (0.32)	43.0 (0.34)	42.5 (0.28)	42.4 (0.57)	42.3 (0.27)		
Pocatello-72	43.7 (0.37)	43.2 (0.39)	43.3 (0.35)	42.7 (0.38)	43.2 (0.24)	43.0 (0.30)	43.2 (0.34)	42.7 (0.42)
Elkhorn-73							42.2 (0.30)	
Bear Lake-76								41.9 (0.37)
Idaho Falls-67	43.4 (0.54)	43.5 (0.35)	42.8 (0.38)	42.6 (0.27)	42.8 (0.25)	43.6 (0.21)	43.8 (0.29)	43.1 (0.42)
Medicine Lodge-59A			41.9 (0.43)					
Marsh Canyon-50				41.7 (0.36)				
Wolverine Canyon-69					43.2 (0.23)			
Tex Creek WMA-69								44.0 (0.23)
Sand Creek-60A						43.0 (0.24)		
Birch Creek-58							42.6 (0.35)	
Tower Creek-21A								41.7 (0.23)
Salmon-28	43.0 (0.41)							
Salmon-30		41.0 (0.38)				41.2 (0.25)	42.6 (0.37)	
Challis-36B	42.2 (0.39)	41.5 (0.31)	42.0 (0.34)	42.4 (0.33)	41.3 (0.24)	41.2 (0.31)	41.9 (0.27)	41.3 (0.36)

Table 9. Mean chest girth (SE) in cm of radio-collared mule deer fawns in central and south Idaho.

Category Group	Dec 1998- Jan 1999	Dec 1999- Jan 2000	Dec 2000- Jan 2001	Dec 2001- Jan 2002	Dec 2002- Jan 2003	Dec 2003- Jan 2004	Dec 2004- Jan 2005	Dec 2005- Jan 2006
Overall								
All fawns	78.4 (0.33)	77.3 (0.35)	76.7 (0.34)	76.3 (0.34)	75.9 (0.36)	76.6 (0.29)	78.0 (0.34)	74.8 (0.36)
Fate								
Lived	79.2 (0.37)	77.6 (0.42)	77.2 (0.40)	77.0 (0.46)	77.0 (0.40)	77.5 (0.38)	77.9 (0.37)	75.8 (0.62)
Died	76.6 (0.59)	76.7 (0.62)	75.4 (0.65)	75.8 (0.47)	73.5 (0.65)	75.6 (0.44)	78.2 (0.85)	74.3 (0.44)
Sex								
Males	79.0 (0.46)	78.0 (0.48)	77.8 (0.49)	77.7 (0.45)	76.9 (0.49)	77.4 (0.40)	78.6 (0.47)	75.8 (0.46)
Females	77.9 (0.46)	76.6 (0.50)	75.8 (0.46)	75.1 (0.46)	74.8 (0.51)	75.8 (0.43)	77.4 (0.50)	73.9 (0.53)
Study areas								
Hells Canyon-22/31			79.4 (1.13)	81.3 (1.33)		79.5 (1.12)		
Dodson Pass-32A			79.4 (1.10)					
Sulphur Gulch-32				76.1 (1.11)	76.4 (1.06)	74.5 (0.67)	77.8 (0.84)	75.0 (0.73)
Boise-39	80.0 (1.06)	79.6 (1.00)	76.0 (1.13)	77.3 (0.85)	72.5 (0.82)	75.6 (0.88)	77.4 (0.66)	73.9 (0.75)
Garden Valley-33							80.6 (0.92)	72.9 (1.24)
Twin Falls-54	78.3 (0.88)	75.3 (1.09)	75.0 (1.03)	77.8 (0.77)	76.0 (0.81)	77.0 (0.91)	78.7 (1.24)	73.6 (1.17)
SE ID Research-56	78.2 (0.84)	76.8 (0.82)	76.1 (0.92)	76.2 (1.28)				
SE ID Research-73A	78.9 (0.77)	77.2 (0.83)	76.9 (1.01)	74.4 (0.76)	77.2 (1.54)	77.2 (0.79)		
Pocatello-72	77.4 (0.88)	79.9 (1.00)	76.6 (1.01)	75.9 (1.06)	79.6 (0.90)	77.0 (0.82)	79.3 (1.61)	78.1 (0.85)
Elkhorn-73							75.4 (1.61)	
Bear Lake-76								76.1 (1.45)
Idaho Falls-67	78.5 (1.30)	80.3 (0.92)	77.2 (1.13)	78.2 (1.16)	78.9 (0.61)	80.5 (0.83)	78.0 (0.81)	73.6 (1.08)
Medicine Lodge-59A			76.5 (1.26)					
Marsh Canyon-50				73.9 (0.95)				
Wolverine Canyon-69					75.0 (0.76)			
Tex Creek WMA-69								77.1 (0.89)
Sand Creek-60A						77.7 (0.74)		
Birch Creek-58							75.6 (0.96)	
Tower Creek-21A								73.2 (1.29)
Salmon-28	79.5 (0.98)							
Salmon-30		74.1 (0.98)				74.0 (0.75)	79.0 (1.08)	
Challis-36B	77.4 (0.94)	75.9 (0.79)	75.2 (0.99)	74.7 (0.72)	72.5 (0.87)	73.0 (0.74)	77.6 (1.17)	74.6 (1.33)

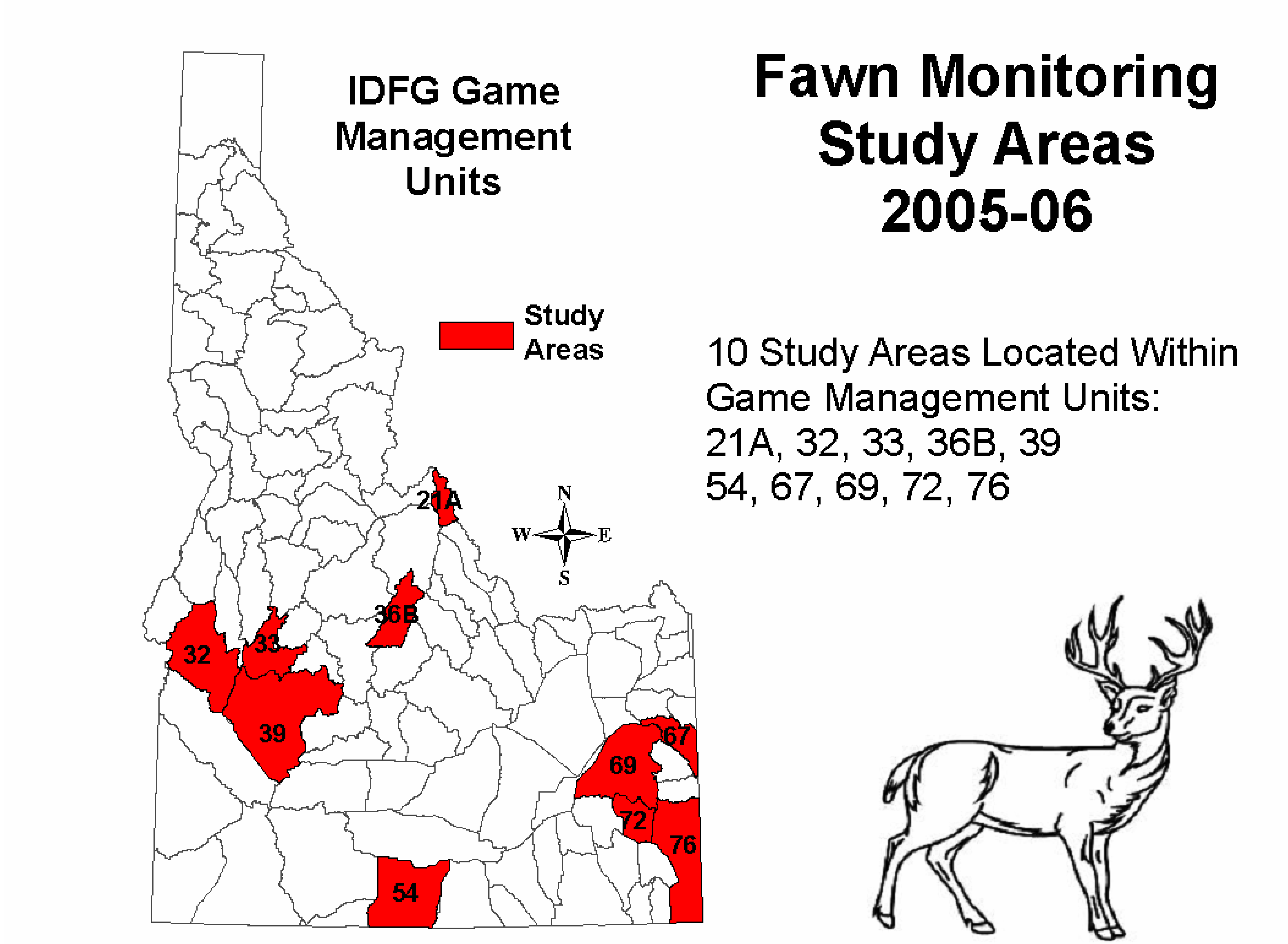

Figure 1. Location of winter range study areas for monitoring mule deer fawn mortality in central and south Idaho.

COMPLETION REPORT
STATEWIDE WILDLIFE RESEARCH

STATE:	Idaho	**JOB TITLE:**	Mule Deer Ecology
PROJECT:	W-160-R-33		
SUBPROJECT:	35	**STUDY NAME:**	Mule Deer Population Modeling
STUDY:	II		
JOBS:	1-2		

PERIOD COVERED: July 1, 2005 to June 30, 2006

MULE DEER POPULATION MODELING

Abstract

Population and harvest data have been collected for the past year but not integrated into a geographical information system (GIS). A number of GIS layers of landscape attributes have been integrated into a GIS projected in Idaho Transverse Mercator (ITM) coordinates. These layers include the 1998 Idaho vegetation layer (GAP Analysis [30 m cell size]), Digital Elevation Models (DEM [90 m cell size]), InterColumbia Basin Ecosystem Management Project (ICBEM) precipitation model, GMUs, and Idaho's rivers, roads, and cities. Other layers will be incorporated based on potential relevance to mule deer population dynamics. Winter and summer range layers of the selected trend populations used for fawn monitoring will be developed as well. Population modeling objectives are long-term and will not be addressed before several years of data have been accumulated.

We began preliminary modeling to predict fawn survival in the permanent study areas in 2006. Six climatic variables and 1 habitat variable were found to be significantly related to fawn survival through the winter months. In each case, the variables were modeled with period-specific effects. *F*-tests invariably found the covariates were better modeled with period-specific effects rather than a common effect across all periods. The fitted models explained 67.2% of the overall variability in fawn survival estimates. The adjusted *r*-squared was estimated to explain 94.0% of the variability in actual survival values (i.e., r^2_{Adj} = 0.940). Modeling efforts will continue with models tested using the non-permanent study areas.

The purpose of GIS is to organize and store large amounts of spatial information in a computer. With recent technological advances in computer resources, GIS has become an effective tool for wildlife management. GIS can be used to classify and integrate landscape features such as habitats, soils, topography, geological features, precipitation regimes, rivers, roads, etc. into a single computer database. GIS can be constructed at any spatial scale dictated by the precision of data collected.

With the statewide change in mule deer population monitoring (IDFG 1998), as described in Study I, the Department has a unique opportunity to look at meta-population dynamics at a landscape level. Similar population data will be collected simultaneously from trend areas across the state. By incorporating a statewide GIS database of various landscape attributes, biologists can begin assessing how large-scale differences in habitats, precipitation, terrain, etc. affect mule deer population performance. Evaluating the role of habitat is very important because mule deer habitat quality may be declining in many of our historic deer ranges. Use of GIS technology is the most efficient and effective means to analyze large-scale deer habitat use. A GIS database will also improve our ability to model populations by considering a greater number of variables which may explain substantial variation between differing populations.

GIS is also the best means for the Department to summarize, organize, and store mule deer population and habitat data. Any type of data can be incorporated into the database; GIS is not limited to spatial information. For example, harvest data can be included for each GMU which can then be associated with habitat types, road densities, elevation, slope, land ownership, sex and age ratios, and so on. Once the GIS has been developed, ArcView® software (ESRI 1996) will enable biologists to view and analyze the data.

Much of the spatial data necessary to construct a GIS for mule deer is already available. GIS layers of roads, rivers, counties, GMUs, terrain, etc. already exist. Other layers such as habitats, soils, and precipitation have been created as well, but at a variety of spatial scales with variable accuracy. A statewide GIS database has already been developed for elk, much of which can be applied to mule deer. Capitalizing on current GIS technology will improve our ability to manage mule deer on a statewide basis.

Through coordinated efforts in collection of mule deer population data, a statewide GIS database will provide a means to enter data into a single database referenced to a number of habitat-related variables. Modeling efforts will be improved by incorporating a greater number of variables which may explain variation among differing population dynamics. Department biologists will be able to access statewide mule deer population and habitat data from a single database.

Study Area

Nine winter range trend areas were selected as study areas across central and southern Idaho in the Southwest, Magic Valley, Southeast, Upper Snake, and Salmon regions. The McCall study area (44°06’, 116°30’) is located in GMUs 32 and 32A north of Emmett. Terrain comprises rolling foothills and benches; elevations range from 2,500-5,000 feet. Vegetation is dominated by sagebrush (*Artemisia* spp.) and grassland habitat types with occasional agricultural lands on the southern border. Willow (*Salix* spp.) and aspen (*Populus tremuloides*) occur in some drainage bottoms. The Boise study area (43°35’, 116°02’) is located in GMU 39 on the Boise River WMA to the northwest of Lucky Peak Reservoir. Terrain consists of relatively steep canyon breaks and elevations range from 3,100 feet at Lucky Peak Reservoir to 5,200 feet near Lucky Peak. Vegetation comprises sagebrush-grass habitat types and a portion of the area burned in 1992. The Twin Falls study area (42°21’, 114°21’) is located in GMU 54 in the South Hills. Terrain comprises rolling hills dissected by several major drainages with elevations ranging from 4,150-5,900 feet. Vegetation is composed of sagebrush-grass habitat types with scattered pockets of bitterbrush. The Pocatello study area (42°43’, 111°43’) is located in GMU

72 in the Soda Hills. Terrain consists of rolling hills and open valleys; elevations range from 5,800-6,800 feet. Vegetation consists of sagebrush-grass habitat types at lower elevations with juniper and mountain mahogany habitats above; aspen and Douglas-fir sites occur on north slopes and high ridges. The Idaho Falls study area (43°40', 111°25') is located in GMU 67 near the South Fork of Snake River. Terrain is moderate to steep with elevations from 5,000-6,700 feet. Vegetation is dominated by sagebrush and mountain shrub with some juniper habitat types. The Challis study area (44°26', 114°15') is located in GMU 36B around Centennial Flat. Terrain comprises rolling foothills cut by small drainages with steep mountain slopes above; elevations range from 5,200-8,300 feet. Vegetation consists of sagebrush-grass habitat types and occasional mountain mahogany with conifer patches at higher elevations. The Salmon study area changed from GMU 28 near Smedley (45°11', 113°56') to GMU 30 on the outskirts of Salmon near Warm Springs and Reese Creek (45°01', 113°34') in 1999-2000. Vegetation consists of sagebrush-grass habitat types in the foothills with conifer patches at higher elevations; elevation ranges from 4,700-9,000 feet. GMUs 56 and 73A are the 2 study areas in the southeast Idaho mule deer research project; refer to Hurley and Unsworth (1999) for study area descriptions. These 2 areas are referred to as the SE Idaho research areas.

Job 1. GIS Layers of Mule Deer Population Parameters and Landscape Features

Objectives

The objectives are to synthesize mule deer population monitoring and harvest data from across the state into a GIS layer referenced to GMUs, and to compile coverages of various landscape attributes potentially relevant to mule deer fitness.

Methods

Existing GIS layers of landscape features relevant to mule deer ecology will be integrated into 1 GIS. Mule deer population monitoring and harvest data from across the state will be referenced to the GIS in terms of GMUs, or sub-units if appropriate. The GIS will be constructed using ARC/INFO® software (ESRI 1995, 1997). Once completed, various statistical analyses will be used to model population performance and changes across the state. Our efforts will be focused on trend areas where estimates of over-winter fawn survival are obtained.

<u>GIS Layer of Population Parameters</u>

Population size and age and sex ratios will be estimated using aerial flights in randomly selected sub-units (within selected GMUs) in each region. We will fly herd composition in late December and early January and conduct population counts in mid-winter and early spring. Program Aerial Survey (Unsworth et al. 1994) will be used to correct population counts for visibility bias. We will follow protocol described in Study I to estimate over-winter fawn survival rates and net recruitment. Harvest data will be obtained through telephone surveys, check stations, and/or hunter mandatory report forms. Once surveys are completed for the year, data will be obtained from the wildlife manager in each region. Population and harvest data for each GMU will be synthesized into a database and linked to a GIS coverage of GMUs using

ARC/INFO® (ESRI 1995, 1997). The Department has already created a geo-referenced coverage of GMUs for the state.

GIS Layers of Selected Landscape Attributes

A variety of statewide GIS coverages of landscape features are available on the Internet. Some of these data layers have a relatively large resolution (~1 km^2) but are acceptable for a landscape-level analysis. The 1998 Idaho vegetation layer (Gap Analysis) has a 30 m cell size and will be used to model habitat features among the fawn monitoring trend areas. DEMs will be used to obtain elevations, slopes, and aspects of trend areas. The Gap vegetation data and DEMs will be downloaded from the University of Idaho's Landscape Dynamics Lab website (http://www.uidaho.wildlife.edu) along with GIS layers of Idaho land ownership, roads, and rivers and streams. Additional GIS data from adjacent states (OR, UT, MT, WY) will also be used, including GAP layers of vegetation/landcover and DEMs, to encompass summer and winter ranges of mule deer that cross state boundaries. We will obtain climate (precipitation, minimum/maximum temperatures, freeze potential) and fire (location, extent) data from the ICBEM website (http://www.icbemp.gov/spatial/html/gis-theme.html). We will also download other GIS layers from the ICBEM website which may be relevant to mule deer. These include potential vegetation, nutrient availability, net primary productivity, grazing allotments, and other political boundaries. The Idaho Department of Water Resources website (http://www.idwr.state.id.us/idwr/idwrhome.htm) contains relevant GIS data which may be used as well. Additional bioclimatology GIS data may be obtained from the National Center for Atmospheric Research (http:/www.ntsg.umt.edu/bioclimatology/daymet).

These various GIS layers will be projected in ITM coordinates using ARC/INFO® (ESRI 1995, 1997) and combined with the GMU coverage containing mule deer population data. Mule deer winter ranges will be delineated using 95% kernel home ranges. Summer ranges will be defined by 4 km radius buffers around summer deer locations. The mule deer GIS database will then be used to model mule deer populations across central and southern Idaho (described in Study II, Job 2).

Results and Discussion

A number of GIS layers of landscape attributes have been integrated into a GIS projected in ITM coordinates. These layers include the 1998 Idaho vegetation layer (GAP Analysis [30 m cell size]), DEMs (90 m cell size), Oregon and Utah GAP vegetation and DEM layers, ICBEM precipitation model, GMUs, and Idaho's rivers, roads, and cities. Other layers will be incorporated based on potential relevance to mule deer population dynamics. Winter range layers of the selected trend populations used for fawn monitoring have been generated and queried for vegetation type, elevation, and slope. Summer range layers are being developed as well. Spring/summer locations of radio-collared deer were obtained for all of the fawn survival study areas to identify summer use areas in 2004 and 2005.

Job 2. Population Modeling

Objectives

The purpose of this job is to identify variables which influence mule deer recruitment and population growth and to project future population trends using statistical modeling techniques. Our long-term objectives are to determine whether: 1) population size, over-winter fawn survival rates, or age and sex ratios vary across selected GMUs in central and south Idaho; 2) differences in habitat types or mean seasonal precipitation influence mule deer fawn survival or recruitment across central and southern Idaho; 3) mule deer densities on winter range influence over-winter fawn survival; and 4) harvest rates of adult female mule deer influence net annual recruitment.

Methods

Differences in Population Parameters

Over-winter fawn survival rates will be estimated and contrasted among trend areas as described in Study I. Program CONTRAST (Sauer and Williams 1989) will be used to test for differences in fawn:doe ratios between GMUs encompassing each trend area. The standard error for each ratio estimate will be calculated following Krebs (1989:205-209). Similar to Program CONTRAST, Program Aerial Survey (Unsworth et al. 1994) will be used to test for differences in corrected population estimates between GMUs corresponding to each trend area.

Modeling Over-winter Fawn Survival

We used proportional hazards modeling to determine effects on fawn survival and to develop a model that can be used to successfully predict fawn survival through winter. The analysis was based on radio telemetry data, assuming a binomial error structure and a log-log link for the proportional hazards model, using Program SURPH (http://www.cbr.washington.edu/paramest/surph/).

In this modeling effort, the winter was divided into 5 periods and the covariate effects were permitted to be either period-specific or common across all periods. Almost invariably, any significant covariate effect resulted in a significant period interaction, requiring unique effects in each period.

Stepwise regression was used to construct the survival model. At each step in the sequential process, the most significant variable conditional on the presence of the other variables already in the model was added. Inevitably, those models also had the smallest Akaike information criterion (AIC) score. Variables were entered as long as they were statistically significant ($P < 0.05$) and AIC scores declined. After all important individual variables had entered the model, all possible 2-way interactions among those variables were examined. Interactions were included in the model using the same entry criteria as the individual variables.

Variables considered in the model will include: early winter fawn mass (kg); fawn hind foot length (cm); fawn chest girth (cm); precipitation combinations (cm) to reflect seasonal changes to plant phenology and deer energy expenditure; minimum monthly October-March temperature (°C); deer density (no./km^2); elevation (m); aspect (°); percent conifer, juniper, mountain brush, big sagebrush (*Artemisia tridentata*), low sagebrush (*A. arbuscula*), and grass; and habitat interspersion. With the exception of cover types, independent variables represent a mean value for the summer and winter range study area. Both summer and winter ranges were defined by estimating a seasonal 95% kernel home range using telemetry locations of all marked deer. Weather and habitat data was then clipped from GIS layers for summer and winter range for each of the permanent study areas. A multivariate statistical technique may be used to reduce the large number of variables to a smaller, meaningful set of variables to prevent over-dispersion in the regression model.

Projecting Future Population Trends

An existing Leslie matrix model (Leslie 1945, 1948; Lefkovitch 1965) for mule deer (J. Unsworth, IDFG, unpublished) will be used to model population change through time by incorporating key parameters from this study. There is a separate model for females and males. Necessary population parameters for the model include fawn survival, adult female survival, adult male survival, yearling and adult female reproductive rates, and initial age structure. The model is flexible and intended to be used as a tool for wildlife managers. For instance, survival rates can be entered as an average rate over time to project a long-term population trend. To more accurately model year-to-year population fluctuations, annual estimates of survival can be entered when sufficient data has been collected. When long-term survival data is not available, stochasticity can be factored into the model by allowing survival rates to fluctuate randomly following a normal distribution. As more data is collected in this study, managers will be able to tailor the model specifically to their study area(s). The model will provide managers with a means of predicting population changes in response to different management options. In particular, the model can be used to evaluate different rates of doe harvest on the population.

Results and Discussion

We began preliminary modeling to predict fawn survival in the permanent study areas. Climatic variables and 1 habitat variable were found to be significantly related to fawn survival through the winter months (Tables 10 and 11). The 6 climatic variables were:

1. Minimum monthly temperature.
2. January-March precipitation.
3. October precipitation.
4. Previous January-March precipitation.
5. April-July precipitation.
6. October-March minimum temperature.

and the habitat variable was Winter IJI, defined as “interspersion and juxtaposition index for the winter sagebrush patch cover type.” Two interactions among these variables were found to be important, namely,

1. Minimum monthly temperature × October-March minimum temperature.
2. Minimum monthly temperature × Winter IJI.

In each case, the variables were modeled with period-specific effects. *F*-tests invariably found the covariates were better modeled with period-specific effects rather than a common effect across all periods. The fitted models explained 67.2% of the overall variability in fawn survival estimates. The adjusted *r*-squared was estimated to explain 94.0% of the variability in actual survival values (i.e., r^2_{Adj} = 0.940).

Table 10. Analysis of deviance (ANODEV) table for the best fit model predicting fawns survival from 2001-2006. Significant P-values are in bold. Overall model explained 67.20% of the variability in the data.

Source	DF	Deviance	Mean deviance	*F*	*P*
$Total_{Cor}$	179	519.92			
Main Effects					
Minimum monthly temperature	5	136.90	27.38	21.52	<0.0001
January-March precipitation	5	56.46	11.29	8.87	<0.0001
October precipitation	5	30.22	6.04	4.75	0.0005
Previous January-March precipitation	5	21.84	4.37	3.43	0.0060
April-July precipitation	5	26.76	5.35	4.21	0.0014
Winger IJI	5	22.20	4.44	3.49	0.0054
October-March minimum temperature	5	22.46	4.49	3.53	0.0050
Interaction					
Min. monthly temp: October-March	5	16.70	3.34	2.62	0.0268
Min. monthly temp: Winter IJI	5	15.86	3.17	2.49	0.0341
Error	134	170.52	1.27		

Table 11. Akaike information criterion (AIC) scores for the sequential fit of models for describing over-winter survival of mule deer fawns (2001-2006).

Model	AIC
Minimum monthly temperature	2098.29
+ January-March precipitation	2051.83
+ October precipitation	2031.62
+ Previous January-March precipitation	2019.78
+ April-July precipitation	2003.02
+ Winter IJI	1990.82
+ October-March minimum temperature	1978.37
+ Minimum monthly temp. × October-March minimum temperature	1971.66
+ Minimum monthly temperature × Winter IJI	1965.80

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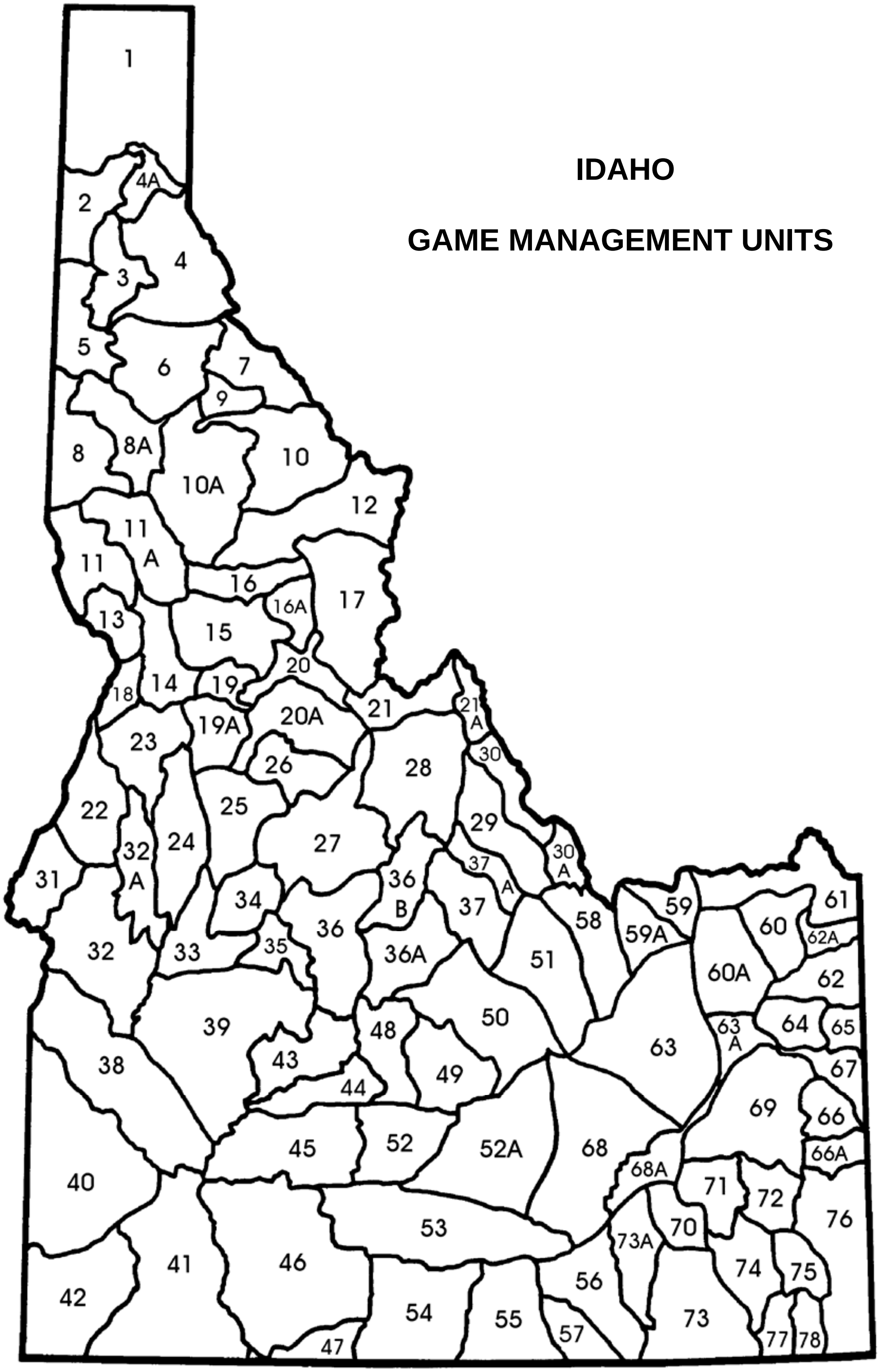
GAME MANAGEMENT UNITS



FEDERAL AID IN WILDLIFE RESTORATION

The Federal Aid in Wildlife Restoration Program consists of funds from a 10% to 11% manufacturer's excise tax collected from the sale of handguns, sporting rifles, shotguns, ammunition, and archery equipment. The Federal Aid program then allots the funds back to states through a formula based on each state's geographic area and the number of paid hunting license holders in the state. The Idaho Department of Fish and Game uses the funds to help restore, conserve, manage, and enhance wild birds and mammals for the public benefit. These funds are also used to educate hunters to develop the skills, knowledge, and attitudes necessary to be responsible, ethical hunters. Seventy-five percent of the funds for this project are from Federal Aid. The other 25% comes from license-generated funds.