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Progress Report

STATEWIDE UNGULATE ECOLOGY

Study I: Population Performance of Mule Deer and Elk Populations
Study II: Effects of Predation on Mule Deer and Elk Populations
Study III: Effects of Habitat and Nutrition on Mule Deer and Elk Populations

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PROGRESS REPORT
STATEWIDE WILDLIFE RESEARCH

STATE:	Idaho	**JOB TITLE:**	Statewide Ungulate Ecology
PROJECT:	W-160-R-34		
SUBPROJECT:		**STUDY NAME:**	Population Performance of Mule Deer and Elk Populations
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POPULATION PERFORMANCE OF MULE DEER AND ELK POPULATIONS

Abstract

We measured survival and cause-specific mortality of adult female mule deer and elk in Idaho during 2005-2006 and 2006-2007. Survival of mule deer was similar across both years ranging from 0.83 in 2005-2006 to 0.86 in 2006-2007. Likewise, cow elk survival was 0.86 in 2005-2006 and 0.88 in 2006-2007. Predation and hunter harvest were the most common proximate causes of mortality. Losses to malnutrition we negligible.

Job 1. Survival, Cause-specific Mortality, and Pregnancy Rates of Elk and Mule Deer in Idaho

Introduction

Mule deer and elk are Idaho's most important big game animals. Currently, a range of 78,000 to 84,000 hunters participate in Idaho elk hunts and harvest over 16,000 elk, while over 110,000 mule deer hunters harvest 23,000 to 26,000 mule deer. In 2001, deer hunting in Idaho contributed over $181,000,000 in economic benefits to the state, including nearly 2,000 jobs and 1.3 million dollars in state tax revenues (IAFWA 2002). More than half of all deer hunting in Idaho is dedicated to mule deer. Elk hunting in Idaho contributes over 150 million dollars to the state's economic condition (Cooper and Unsworth 2000).

Mule deer populations in Idaho have followed a trend similar to populations across the western United States. Mule deer generally achieved high historical densities in the 1950s and 1960s followed by significant declines across the western states. These declines have been the subject of intense debates within professional circles (Workman and Low 1976) and among the hunting public. More recently, populations in Idaho and some surrounding states experienced growth through the 1980s and a subsequent decline in the 1990s (Compton 2004*a*). There is little consensus and, even less definitive evidence, on the causes driving these trends.

Elk populations in Idaho grew steadily into the 1960s and subsequently declined until general, antlerless hunting was discontinued in 1975. Subsequently, populations grew steadily through the 1980s. Over much of the more arid habitats of southern Idaho, elk populations grew and expanded into previously unoccupied habitats. In the late 1980s, calf recruitment began

declining in many areas of Idaho (Compton 2004*b*). In the more productive areas, recruitment rates declined from high levels to moderate levels, while in less productive areas, recruitment rates declined to extremely low levels, often below 15 calves:100 cows. Low recruitment led to declining populations, which precipitated intense interest in the problem. Since that time, elk research in Idaho has focused on the causes of elk calf recruitment.

Habitat potential is generally recognized as the ultimate determinant of population density. Ungulate populations are limited to habitat potential and vital rates presumably respond in a density-dependent fashion (Caughley 1977). The classic model of ungulate population growth assumes a logistic form with the inflection point, and associated maximum growth rate, at approximately half of carrying capacity. However, some evidence suggests that yield is asymptotic nearer the upper level of population potential. Regardless, the fundamental assumption is that habitat, primarily forage, and its effect on animal condition regulates population growth, yield, and density. As populations approach habitat potential, yield approaches zero. In ungulate populations, the functional response may be reflected in lower survival of subadults, primarily neonates, and lower subadult fecundity (Cook et al. 2004).

The literature is replete with accounts of ungulate mortality factors running the full gamut from additive to compensatory variously depending on predator and prey population densities, habitat conditions, alternate prey, and a variety of other factors including human exploitation. Connolly (1978) cited 45 references that tended to support the hypothesis of population regulation by predators, and another 27 that suggested predation was compensatory. Predation was identified as a controlling factor (Keith 1974), limiting factor (Bergerud et al. 1983, Bergerud and Snider 1988, Larsen et al. 1989), and regulating factor (Messier and Crete 1985, Ballard et al. 1990) of North American ungulate populations. However, Thompson and Petersen (1988) challenged the conclusion of Bergerud et al. (1983) that wolf predation limited moose populations in 2 areas, and Boutin (1992) questioned the wide acceptance of predation as the major regulatory factor of moose. In general, much of the work failed to consider alternate explanations and failed to test hypotheses with experimental manipulation.

In some instances, experiments were conducted providing more reliable evidence. Gasaway et al. (1983) revealed a significant increase in moose calf recruitment and population growth in areas with wolf removal while there was no change in control areas. In another area, moose recruitment did not change with wolf removal (Ballard et al. 1987), but did increase with bear removal (Ballard and Miller 1990). Experimental manipulation in the Yukon revealed that wolf predation limited caribou and moose recruitment, and adult moose survival, but did not affect adult caribou survival or Dall sheep recruitment and survival (Hayes et al. 2003).

Zager and White (2003) found that elk calf survival increased with a reduction in black bear and mountain lion densities in Game Management Unit (GMU) 12, while survival declined when predator densities were increased in GMU 15. These findings might corroborate the previous work of Schlegel (1976) who demonstrated increased elk calf survival following the removal of black bears. This work suggests an additive component of calf elk losses to predation.

Mortality is expected to be largely compensatory when population density is near habitat potential. Bartmann et al. (1992) demonstrated a strong compensatory element of mule deer

fawn mortality in both a penned and free-ranging setting. When coyote densities were reduced, coyote-caused mortality decreased while starvation increased. Fawn survival was directly related to fawn weights, and varied inversely with density in penned pastures. Similarly, Clutton-Brock et al. (1987) demonstrated a density-dependent decrease in calf survival with increasing red deer (*Cervus elaphus*) cow density. Franzmann and Schwartz (1986) found a relationship between habitat quality and bear predation on moose calves. In Yellowstone National Park, winter elk calf mortality was inversely related to elk population density, and summer mortality was related to birth weight (Singer et al. 1997). Moreover, calves killed by predators tended to be late-born and lighter.

Predation

Bears may be a significant predator of ungulate neonates. A combination of black bears and brown bears took 34-52% of radio-collared moose calves in Alaska and the Yukon (Ballard et al. 1981, 1990; Larsen et al.1989; Schwartz and Franzmann 1990). In each case, bear mortality was the largest proximate source of mortality and Larsen et al. (1989) concluded that bear predation was the most significant limiting factor of moose on their study area.

Schlegel (1976) found that black bears took at least 67% of radio-collared elk calves that died at Coolwater Ridge in Idaho. The current research effort revealed a similar magnitude of black bear-caused mortality in GMUs 10 and 12, with lesser bear-caused mortality in GMU 15 (Zager and White 2003). Singer et al. (1997) found relatively low black bear predation on calves (3% of deaths), while grizzly bears caused 28% of calf deaths. Myers et al. (1996) found that black bears accounted for 21% of elk calf deaths. Van Ballenberghe and Ballard (1994) argued that bear predation on moose calves is additive and density dependent.

In southern Idaho, black bear predation was not detected on mule deer fawns (Hurley et al. In prep). However, their study areas were located in areas of low black bear occurrence. In mule deer habitats with higher black bear densities, bear-caused fawn mortality may be a factor.

Mountain lions consume a wide variety of foods including lagomorphs, rodents, and small predators, but deer typically dominate their diet (Robinette et al. 1959, Hornocker 1970, Toweill and Meslow 1977, Ackerman et al. 1984, Hemker et al. 1984). Mountain lions are significant predators of elk (Hornocker 1970, Schlegel 1976, Myers et al. 1996, Singer et al. 1997, Smith and Anderson 1998, Zager and White 2003).

Coyote predation of mule deer fawns and elk calves is well documented (Hamlin and Schweitzer 1979, Johnson and Hansen 1979, Gese and Grothe 1995, Singer et al. 1997, Hurley et al. In prep). The findings of Hurley et al. (In prep) revealed that, while coyotes prey heavily on mule deer fawns in southern Idaho, efforts to reduce coyote densities to improve fawn survival are largely ineffective.

In 1995 and 1996, 35 gray wolves were reintroduced into Idaho under provisions of the Endangered Species Act. From the initial 35, wolf numbers subsequently increased to 71 in 1997 and by December 2004, at least 400 wolves were present in Idaho. Wolf populations continue to grow as new packs form and wolves spread into previously unoccupied areas.

Wolf diets throughout the world tend to be highly variable, but wolves tend to subsist largely on ungulates, where they are available. In the multiple ungulate systems of the northern Rocky Mountains, wolves tend to select elk over other ungulate prey (Huggard 1993, Husseman et al. 2003). Huggard (1993) suggested elk were selected over deer because large elk groups could be found in predictable locations.

Like other predators, wolves tend to select more vulnerable prey. Several investigations revealed that wolves select elk that are old, young, or somewhat debilitated (Carbyn 1983, Kunkel et al. 1999). Wolves also tend to select bull elk, possibly due to lower condition caused by rut activity (Boyd 1994). Data collected in Idaho to date also indicate selectivity for calf elk (Husseman et al. 2003, Compton 2004*b*). Selection for more vulnerable prey suggests a compensatory element to predation, but does not imply that predation is entirely compensatory.

Wolf kill rates tend to be relatively constant over wide ranges of prey densities, although kill rates will decline at very low prey densities (Dale et al. 1994, Eberhardt 1997). Consequently, wolf/prey ratios tend to be better predictors of wolf kill rate than prey densities. This relationship suggests a stronger "top down" (additive) effect of wolf predation. This relationship also implies a mechanism for multiple equilibria. Ungulate yield curves are thought to assume an inverted "U" shape with yield increasing to some optimal ungulate density, then declining as density approaches K (Caughely 1977). If wolf kill rates are constant despite prey density, the wolf and ungulate populations will reach equilibrium at 2 positions, on the lower and upper halves of the yield curve. The management implication is that ungulate populations regulated at low density (equilibrium at lower half of curve), might be released with temporary wolf control to reach the upper equilibrium.

Habitat and Animal Condition

Habitat potential is generally recognized as the ultimate determinant of population density. Elk and deer populations are products of their year-round environment. In general, habitat may influence populations ostensibly through the provision of nutrition and thermal protection. However, the role of thermal cover is questionable (Cook et al. 1998), suggesting nutrition is the primary functional element of habitat. Nutrition is generally recognized as a density-dependent influence on populations. However, density-independent mechanisms (e.g. nutritional inadequacy occurs regardless of ungulate density) may also be important. While habitat selection patterns of mule deer and elk have been studied exhaustively, much less has been done to link habitat conditions, and habitat change, to population demographics.

Recently, more research effort has been directed at linking forage nutrition and weather to specific effects on the level of animal condition, and also to link condition levels to vital rates of populations. Cook et al. (2001) found that poor condition of cow elk may lead to failure to ovulate and breed. Similarly, summer range quality was linked to ovulation rates in mule deer (Julander et al. 1961). Reduced nutritional condition is a function of year-round forage conditions, environmental stresses (e.g., weather), and lactation (Cook et al. 2004). In addition, poor nutrition can lead to delayed breeding in elk (Cook et al. 2001), and late-born young might be predisposed to higher rates of mortality.

Age at first breeding, and consequently, pregnancy rates of younger females, is sensitive to nutrition. Summer-fall nutrition of calves and fawns may strongly influence their probability of becoming pregnant as yearlings (Verme 1967, Cook et al. 2004). Pregnancy rates of yearling deer and elk vary widely among studies, suggesting that yearling pregnancy rates might be a sensitive indication of habitat and nutrition.

Birth weight and growth rate can strongly influence survival of neonates (Thorne et al. 1976, Cook et al. 2004). Juvenile birth weights are influenced by the mother's condition and nutritional intake during pregnancy (Verme 1967, Thorne et al. 1976) and weather during the last trimester (Smith et al. 1996). Early growth is a function of milk yield while later growth is a function of the effect of habitat on calf summer-fall nutrition (Wallmo et al. 1977, Cook et al. 1996, 2004). Furthermore, growth rate may be suppressed by low birth weight (Cook et al. 2004).

The effects of calf condition may interact significantly with predation. For example, Keech et al. (2000) found that birth weight of moose calves strongly influenced the subsequent likelihood of bear and wolf predation. Similarly, Singer et al. (1997) found a relationship between predation rates and birth weights of elk calves. The relationship between predation risk and condition strongly implies compensatory mortality.

Cook (2002) suggested that free-ranging elk populations in many areas of western North America might be limited by forage nutrition. However, Cook's (2002) analysis relied heavily on work with artificial diets in penned settings casting some doubt on the extrapolation to wild elk. Nonetheless, the implications are significant.

Study Areas

The intent of study area selection was to obtain a sample of study areas that represented the range of conditions in Idaho. We identified gradients related to ecotype (soils, vegetation, geology, climate, etc.), land use/ownership, habitat issues, predator densities, ungulate population performance levels and density, alternate prey, and wolf densities. Evaluation of wolf impacts on ungulate population performance is a key element of this work. Consequently, study area selection favored areas with established wolf packs or high potential for colonization. Among the remaining criteria, ungulate population densities and performance levels; alternate prey; and wolf density received the greatest weights.

Methods

Survival and cause-specific mortality rates were determined from samples of radio-marked mule deer does and cow elk. Pollock et al. (1989) suggested a sample of at least 20 for Kaplan-Meier survival estimate at any time, and recommended 40-50 animals be tagged to obtain good precision.

Adult elk and mule deer were captured by helicopter darting or net-gunning, drive nets, and corral traps during winter of each year. Each animal was fitted with a VHF radio collar equipped with mortality sensor. Blood samples were obtained and analyzed for Pregnancy Specific

Protein-B (Biotracking, Moscow, Idaho – Noyes et al. 1997). Chest girth was measured to estimate body weight (Millspaugh and Brundige 1996, Cook et al. 2003).

Deer and elk were monitored biweekly for survival status. If a mortality signal was detected, the carcass was investigated within 24 hours to determine cause of death as described by Hamlin et al. (1984). Survival rates were calculated following the methods described by Pollock et al. (1989).

Results and Discussion

Mule Deer

We analyzed survival rate and fate of adult female mule deer from 1 June to 31 May 2005-2007. This time period was used to coincide with the annual birth pulse and population modeling requirements. Kaplan-Meier procedures were used to estimate survival rates and log-rank tests to compare survival functions between years.

Overall survival was slightly lower in 2005 (S = 0.825, n = 247) than 2006 (S = 0.863, n = 297); however, not statistically (χ^2 = 1.45, P = 0.228) (Tables 1 and 2). The pattern was similar with respect to individual DAUs, except DAU 6. Predation rates were similar between years (6.9% in 2005 and 6.7% in 2006) with mountain lions identified as the primary predator of adult mule deer (Table 3).

Elk

We measured survival of adult female elk from 1 June to 31 May 2005-2007. Causes of death were somewhat similar among years (Table 4). Mountain lion mortality increased from 2005-2006 to 2006-2007 (Table 4).

Survival rates varied substantially among study areas (Table 5). In the Unit 12/10 and Unit 15 study areas, hunter harvest was minor (7% of mortalities), while wolf-caused mortality was substantial (60% of mortality), and mountain lion-caused mortality played a lesser role (12%). In the Unit 33, 35, 39, 43 and Unit 36A, 36B, 28, 50 study areas, cow harvest was significant (33% of mortalities), while both mountain lion (28%) and wolf (16%) predation contributed to observed mortality. In the remaining study areas, cow elk mortality was primarily a function of hunter harvest (48%), while mountain lion (9%) and wolf (3%) predation played minor roles.

Mean pregnancy rates of cow elk among study areas fell within normal ranges for North American elk (Table 6).

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Table 1. Annual survival rates and standard errors (SE) of radio-collared adult female mule deer by Data Analysis Unit.

Category	2005-2006	2006-2007
Group	Survival rate (SE)[a]	Survival rate (SE)[a]
Dates	1 Jun – 31 May	1 Jun – 31 May
Number of adults	247	297
Overall	0.83 (0.024)	0.86 (0.020)
Data Analysis Units		
1	0.85 (0.052)	0.84 (0.059)
2		
3		
4	0.80 (0.037)	0.86 (0.034)
5	0.85 (0.071)	0.95 (0.044)
6	0.83 (0.070)	0.67 (0.086)
7		
8		
9		
10		0.84 (0.054)
11		
12	0.87 (0.088)	0.95 (0.047)
13	0.83 (0.108)	0.96 (0.041)
14		
15		

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

Table 2. Annual survival rates and standard errors (SE) of radio-collared adult female mule deer by Game Management Unit.

Category	2005-2006	2006-2007
Group	Survival rate (SE)[a]	Survival rate (SE)[a]
Dates	1 Jun – 31 May	1 Jun – 31 May
Number of adults	247	297
Overall	0.83 (0.024)	0.86 (0.020)
Study areas		
23	1.00 (0.000)	0.80 (0.103)
28	0.84 (0.084)	0.88 (0.083)
32	0.76 (0.080)	0.87 (0.070)
36A	0.86 (0.064)	0.92 (0.054)
36B	0.79 (0.065)	0.81 (0.069)
39	0.85 (0.071)	0.95 (0.044)
45	0.83 (0.070)	0.67 (0.086)
50	0.73 (0.081)	0.93 (0.050)
51		0.94 (0.063)
58	0.83 (0.108)	
60A	0.87 (0.088)	0.95 (0.047)
69		0.81 (0.086)
72		0.88 (0.068)

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

Table 3. Annual fates of radio-collared adult female mule deer alive on 1 June in central and south Idaho.

Fate	2005-2006	2006-2007
Collars shed or lost prior to 31 May	1	7
Collars retained to 31 May	203	250
Wolf predation	2	1
Coyote predation	1	0
Mountain lion predation	12	6
Other predation[a]	2	13
Malnutrition	2	1
Hunter harvest	12	9
Other[b]	12	10
Total	247	297

[a] Other predation includes predation by unlisted predators or predation was confirmed, but predator species could not be identified.
[b] Other mortality causes include automobiles, trains, fences, and unknown causes of mortality.

Table 4. Annual fates of radio-collared adult female elk alive on 1 June in Idaho.

Fate	2005-2006	2006-2007
Wolf predation	16	21
Mountain lion predation	21	5
Hunter harvest	18	26
Other predation[a]	3	2
Malnutrition	2	0
Other[b]	11	14
Total	71	68

[a] Other predation includes predation by unlisted predators or predation was confirmed, but predator species could not be identified.
[b] Other mortality causes include automobiles, trains, fences, and unknown causes of mortality.

Table 5. Annual survival rates and standard errors (SE) of radio-collared adult female elk by study area.

Category	2005-2006	2006-2007
Group	Survival rate (SE)[a]	Survival rate (SE)[a]
Dates	1 Jun – 31 May	1 Jun – 31 May
Number of adults	615	584
Overall	0.86 (0.014)	0.88 (0.014)
Study areas		
10, 12	0.84 (.040)	0.71 (.055)
15	0.93 (.049)	0.85 (.109)
23, 32, 32A	0.91 (.042)	0.67 (.071)
33, 35, 39, 43	0.87 (.029)	0.89 (.027)
28, 36A, 36B, 50	0.82 (.032)	0.93 (.022)
60A	0.76 (.057)	0.98 (.024)
69, 72	0.98 (.015)	0.98 (.014)

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

Table 6. Pregnancy rates (and sample sizes) of radio-collared elk in Idaho.

Category	2005	2005-2006
Group	Pregnancy rate (*n*)	Pregnancy rate (*n*)
Dates	1 Jan – 31 May	1 Jun – 31 May
Number of adults	197	71
Overall	0.89	0.85
Study areas		
10, 12	1.0 (8)	0.76 (21)
15		
23, 32, 32A	0.94 (34)	
33, 35, 39, 43	0.96 (25)	
28, 36A, 36B, 50	0.82 (103)	1.0 (10)
60A	1.0 (27)	0.91 (11)
69, 72		0.83 (29)

PROGRESS REPORT
STATEWIDE WILDLIFE RESEARCH

STATE:	Idaho	**JOB TITLE:**	Statewide Ungulate Ecology
PROJECT:	W-160-R-34		
SUBPROJECT:		**STUDY NAME:**	Effects of Predation on Mule Deer and Elk Populations
STUDY:	II		
JOB:	1		

PERIOD COVERED: July 1, 2006 to June 30, 2007

EFFECTS OF PREDATION ON MULE DEER AND ELK POPULATIONS

Abstract

We did not conduct any work on Study II during the reporting period.

PROGRESS REPORT
STATEWIDE WILDLIFE RESEARCH

STATE:	Idaho	**JOB TITLE:**	Statewide Ungulate Ecology
PROJECT:	W-160-R-34		
SUBPROJECT:		**STUDY NAME:**	Effects of Habitat and Nutrition on Mule Deer and Elk Populations
STUDY:	III		
JOBS:	1-2		

PERIOD COVERED: July 1, 2006 to June 30, 2007

EFFECTS OF HABITAT AND NUTRITION ON MULE DEER AND ELK POPULATIONS

Abstract

We did not conduct any work on Study III during the reporting period.

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IDAHO DEPARTMENT OF FISH AND GAME

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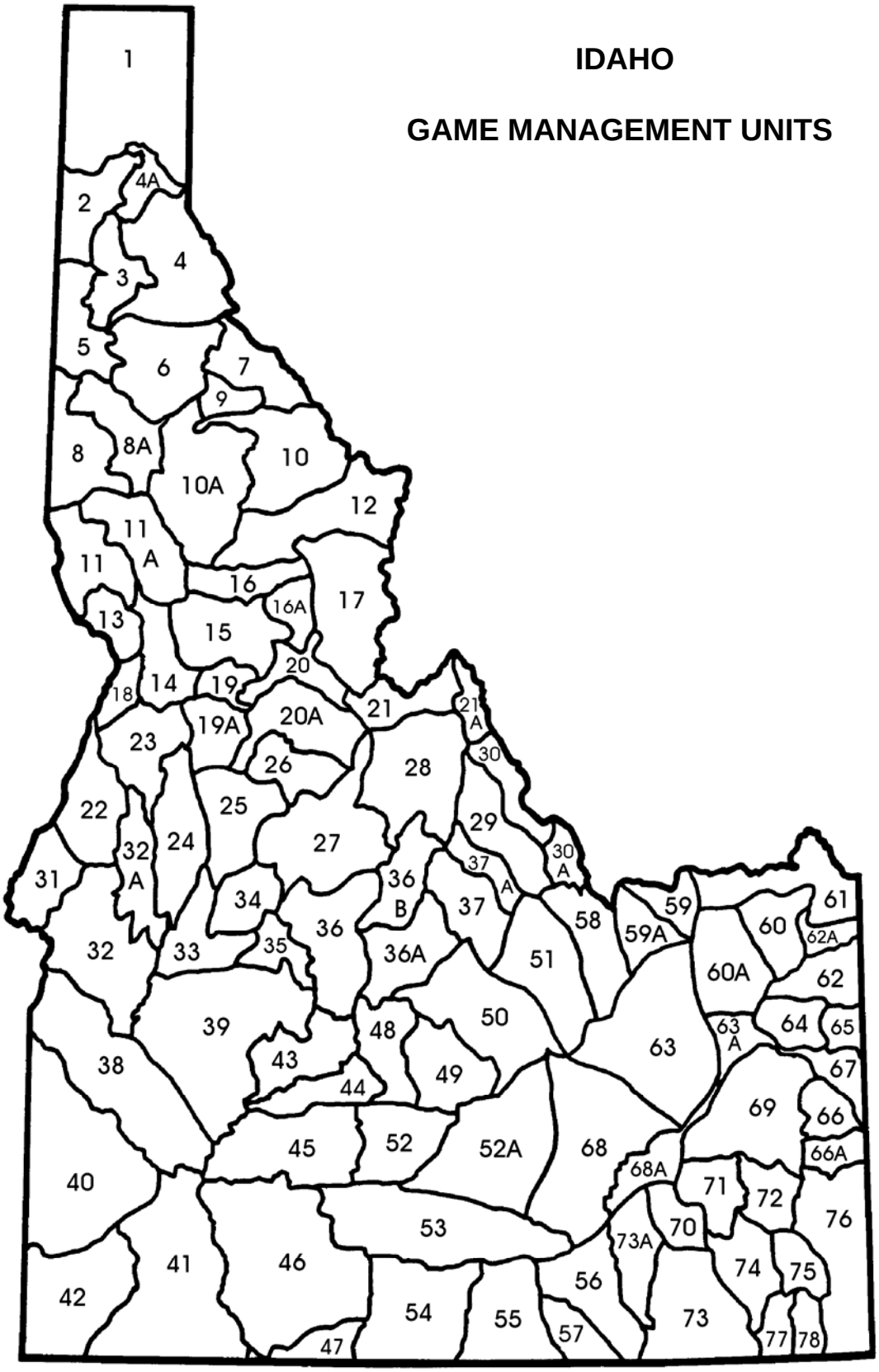
IDAHO

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.