

**IDAHO DEPARTMENT OF FISH AND GAME**

**Cal Groen, Director**

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**Progress Report**



**ELK DATA ANALYSIS PROJECT**

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relationship between dams' summer-autumn nutritional intake and having a nursing calf at heel the year prior to parturition. Changes in nutrition are related to several factors such as climate (Albon et al. 1980), density of ungulates (both domestic and wild) (Albon et al. 1987; Andersen and Linnell 2000), and habitat differences. Another study indicated that both bull and dam age would highly impact calf growth and development by influencing time of conception (Noyes et al. 2000) and parturition, mother fitness (Albon et al. 1980), and extent of maternal care (Andersen and Linnell 2000, Lee et al. 1991). Timing of birth, or birth date may also have an effect because later-born calves may be born bigger due to longer gestation periods; they could grow faster to "make-up" for lost growing time before winter (Cook et al. 1996); or grow slower because abundance of forage offered by spring green up has begun to decline (Albon et al. 1987). In addition, genetic variation within a population could account for differences in size at birth and growth rates of newborn elk calves.

In this study, we expanded on these methods developed to age neo-natal cervids (Haugen and Speake 1958; Johnson et al. 2000; Sams et al. 1996; Smith et al. 1997) and explored relationships between weight gain and nutrition. Using data from captive animals, we had three objectives:

1. Develop a mathematical model to predict neo-natal calf age that can be implemented.
2. Determine if captive calves are representative of elk calves from other experimental and wild populations.
3. Explore the relationships between weight gain and body growth with diet quality of mother, timing of birth, age of mother, and status of calf at heels.

## Results

### Birth weights

Birth weights were compared using ANOVA. When we compared birth weight between sexes, years, and combined Summer-Autumn and Winter Feeding Groups (SAWFG), the overall model was significant ( $P = 0.0042$ ), using  $\alpha = 0.05$ . Both sex ( $P = 0.007$ ) and year by SAWFG interaction was significantly different ( $P = 0.038$ ). Because the year by SAWFG interaction was significantly different, we decided to further explore the differences by conducting a separate analysis on each year. An ANOVA was conducted comparing birth weights from calves born in 1997 ( $n = 34$ ) between sexes and the summer-autumn nutritional treatment. Again, the overall model was significant ( $P = 0.044$ ). Within this model, only sex was significant ( $P = 0.0096$ ). The summer-autumn nutritional treatment was not significant in the model ( $P = 0.661$ ).

An additional ANOVA was used to explore the relationships between birth weights from calves born in 1998 and sex and nutritional feeding group. These calves' mothers were reassigned to a new summer-autumn nutritional feeding group and then assigned to a different winter-feeding. The 1998 nutritional group explored was a combined summer-autumn and winter level (SAWFG) because a full randomization of mothers to winter-feeding groups did not occur. This overall model was significant ( $P = .0081$ ). Both sex ( $P = 0.049$ ) and SAWFG ( $P = 0.022$ ) were significant in the model. Linear, orthogonal contrasts were used to explore where the difference was among the five combinations of SAWFG. Only the combination low-high SAWFG was

significantly different from all of the other groups ( $P = 0.0031$ ). This difference may simply be due to the small sample size found in that group ( $n = 2$ ).

Mean birth weights were detailed by year, sex, and feeding group. These mean birth weights were comparable to mean birth weights from other studies, except for males in the low feeding group in 1997 and the medium-high group in 1998. Males in these two groups had average weight above all of the other groups from this study and other studies (Mean = 19.5,  $n = 1$  and Mean = 20.45, SE = 0.82,  $n = 3$ ). The calves with a high birth weight in each of these two groups were born to the same mother. Mean birth weight from the Cook et al. (1996) study (Mean = 14, SE = 0.0023,  $n = 67$ ) were lower than all mean birth weights from this study. Cook et al. (1996) noted that many calves from his study experienced sickness and diarrhea.

### Repeated Measures Model

Weight measurements were fairly linear. A linear repeated-measures model was used on data from 1997 calves. This model explored relationships between weight gain and sex, mother's summer-autumn nutritional treatment (SAFG), and mother's calf-at-heel status (Did the mother wean a calf during gestation?) and time interactions. The model tested was:

$$\text{Weight} = \text{Age} + \text{Sex} + \text{Calfatheel} + \text{SAFG} + \text{Age*Sex} + \text{Age*Calfatheel} + \text{Age*SAFG}$$

Several autocorrelation structures were added to the model to improve model fit. A toepelitz autoregressive (AR) was implemented because it had the lowest Akaike Information Criterion (AIC) (802.0) when compared to models with autoregressive (AR[1]; AIC = 806), moving average (ARMA) structure (ARMA[1,1]; AIC = 805.0) and compound symmetric (CS; AIC = 1026.4) variance structures. The overall model was significant ( $P = .001$ ) using data from 36 calves with 343 observations. Age ( $P < .001$ ) and sex ( $P = .028$ ) were significant in the model.

Age \* Calfatheel ( $P = .06$ ) was almost significant in the model.

A repeated-measures model was also fit to the 1998 calves. This model explored relationships between weight gain and sex, mother's SWFG, and mother's calf-at-heel status and time interactions. The model tested was:

$$\text{Weight} = \text{Age} + \text{Sex} + \text{Calfatheel} + \text{SWFG} + \text{Age*Sex} + \text{Age*Calfatheel} + \text{Age*SWFG}$$

Again, several autocorrelation structures were added to the model to improve model fit. A toepelitz autoregressive was implemented because it had the lowest AIC (1,105.0) when compared to models with autoregressive (AR[1]; AIC = 1,115), moving average structure (ARMA[1,1]; AIC = 1,117.0) and compound symmetric (CS; AIC = 1,322.5) variance structures. The overall model was significant ( $P = .001$ ) using data from 47 calves with 496 observations. Age ( $P < .001$ ), sex ( $P < .001$ ), Age\*Sex ( $P < .001$ ) and Age\*SWFG ( $P < .001$ ) were significant in the model. Not all of the data could be used in these two analyses, because weight was not collected every day for every calf.

## **Mixed Effects Models for Predicting Age**

Because not all measurements were taken at every period of observation, we only used measurements that contained complete observations. Models were built using 583 observations from 59 calves and 45 elk mothers. Because each mother was re-randomized to a new feeding group and given an additional winter diet, nutritional feeding group was confounded with diet. Because of this, diet could not be used as a nested random effect. Random effects explored include: random calf and mother intercepts and random slopes for weight, hoof, and tooth. Several models were fit and compared with AIC.

A few autocorrelation structures were explored and added to the model. These autocorrelation variance structures greatly improved the fit of the models. A few other autocorrelation structures are available, such as the toepelitz, but we have not yet included these in the models. The current best model includes:

$$\text{Calf age} = -10.6 + \text{Sex} + \text{Weight} + \text{Tooth edge} + \text{Hoof line}$$

Random intercepts: Calf; Random slopes: Weight, Tooth edge, Hoof line

Autocorrelation structure: autoregressive (AR[1])

Although this model did not have the lowest AIC (981.2), it was the model that had a low AIC and met all of the model assumptions. A similar model with an additional random effect for mother had a lower AIC (981.4), but severely violated model assumptions. Model assumptions for the chosen model were graphically explored. Conditional residuals and residuals for each random effect were homoscedastic and normally distributed within and among groups.

Further exploration of autocorrelation structures will be conducted. Then the final model needs to be validated using 10-fold cross validation

## **JOB 2: ESTIMATING SURVIVAL RATES WITH DEMOGRAPHIC AND ENVIRONMENTAL FACTORS FOR ELK IN IDAHO**

Estimating survival rates is important for wildlife managers and biologists because it is a primary demographic used to understand and manage elk populations. Estimates of survival provide insights about the future trajectory of abundance and density of a population. It may also provide a reference for the health of a population. If there were major problems with disease, predation, or hunting, changes in survival would be noted.

Several different methods have been used to explore survival rates and factors affecting survival rates. In a review of the literature of the Journal of Wildlife Management and Wildlife Society Bulletin over the past 13 years, 14 different methods have been used for this type of analysis. Because there are so many methods to choose from, it would be useful to evaluate these methods and determine which approach is the best to estimate survival rates and link differences in survival rates to demographic and environmental factors.

Survival or survivorship is unique because it is measured as a rate. Common regression techniques cannot be used with this type of data because the rate follows a non-normal distribution and the sample set changes throughout time (Hougaard 2000). There are also other unique issues that need to be addressed when working with survival rates, such as the unit of time, time frame of analysis, right censoring, and left truncation. Right censoring occurs when the fate of a study animal is unknown (Hosmer and Lemeshow 1999). This could happen if the animal's radio collar fails or the battery dies; the animal emigrates off the study area temporarily or permanently; topography interferes with relocations; or the animal lives past the end of the study (Winterstein et al. 2001). Left truncation or delayed entry occurs when animals enter the period of observation at different times. The start of the study time for each animal would be when it is radio collared, but each animal may have been captured and radio collared at different times.

We explore various survival analysis techniques and determine which one would be the best method to explore secondary causes for differences in survival.

### **Objectives**

1. Compare survival analysis techniques and identify which one is the most appropriate method to use with this particular data set.
2. Using the best method(s), explore how demographic and environmental factors affect an elk's chance of survival in each of the four populations.

### **Results and Progress**

#### **Subproject 2, Objective 1**

Compare survival analysis techniques and identify which one is the most appropriate method to use with this particular data set.

Several different methods will be evaluated using the four data sets. These methods include Modified Mayfield survival estimates; Non-parametric hazard rate survival estimates; Cox's proportional hazards model; Exponential, Weibull and Gompertz Parametric Survival Models; and Known Fate Survival Analysis methods within Program MARK. All of these have been used to a varying degree in the literature.

These methods are being evaluated for ease of use, flexibility, assumptions, and availability in statistical packages. Details of all of these methods are being explored. Data is being reformatted for each method. Preliminary data analysis trials have been conducted.

#### **Subproject 2, Objective 2**

Using the best method(s), explore how demographic and environmental factors affect elk survival in each of the four populations.

## **Elk Data**

An ACCESS database has been constructed containing elk locations from the four populations. Survival analysis records have been thoroughly checked using both electronic and paper copies. Elk radio locations have been projected and converted to shape files in ArcView. Commission and omission errors of the point locations are being assessed. Additionally, the survival data is being formatted for use in Cox's proportional hazards model.

## **Hunting-related**

We are in the process of gathering hunting-related variables. Number of hunters, number of days hunted, and percent success rate for almost all areas and years have been collected from Idaho Fish and Game annual reports. This data has been added to the survival analysis database. Information regarding type of hunt unit (front range, farm/ranch, etc.), start of season, length of season, and sex and age class targeted during hunt has been collected from annual Idaho Fish and Game regulation guidebooks for almost all years and areas. This data is also being added to the survival analysis database.

## **Demographic-related**

Demographic data, such density estimates from aerial surveys, have been collected from Idaho Fish and Game annual reports for all years and study areas. Because this data was not collected on an annual basis, we are assessing the utility of including it in the analysis.

## **Environmental Factors**

Because some animals in the Sand Creek study area move between Idaho, Montana, and Wyoming, we realized that we would be limited by the spatial layers available for the three states. Topographic features will be collected from the 30 m seamless National Digital Elevation Models (USGS NED). We are in the process of downloading mosaicking grids and projecting the digital elevation data in Arc. Additionally, 30 m seamless National Land Cover data (USGS NLCD) has been downloaded, mosaicked, and projected for all study areas in Arc. Road layers, stream layers, and soil spatial layers are being collected from Idaho, Montana, and Wyoming spatial data repositories. Monthly mean temperatures and precipitation have been collected from Idaho State Climate Service weather stations that were located close to each study site and provided continuous data sets for the time periods studied. Additional daily and weekly temperature and precipitation data are being collected. Once this data is amassed, its utility will be considered for inclusion in a Cox's proportional hazard model.

## **Proposal**

The M.S. thesis was completed in 2005. With the current project, we are supplementing and re-analyzing these data using new statistical approaches. The results will be interpreted and two manuscripts will be developed for submission to appropriate journals. We believe that is the best way to make these valuable tools available to biologists and other interested parties.

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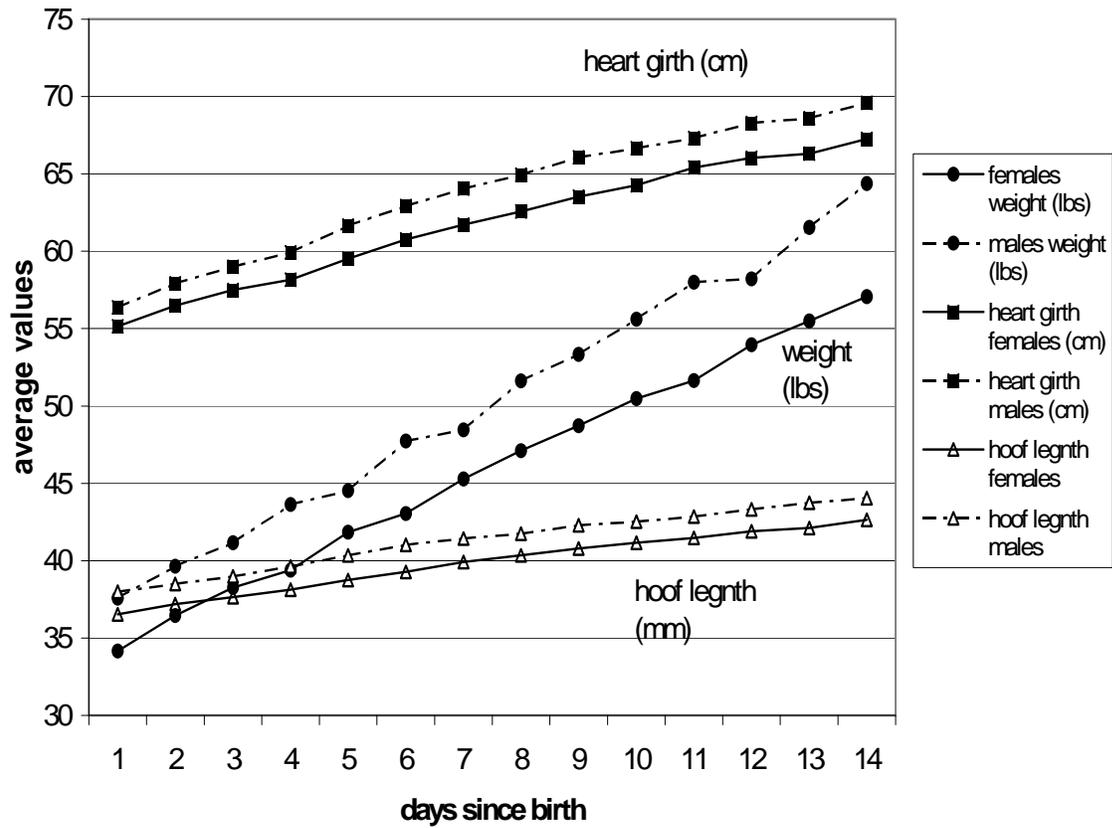


Figure 1. Average weight, hoof length, and heart girth of Rocky Mountain male and female elk calves at Starkey Experimental Forest and Range, Oregon, 1997-1998.

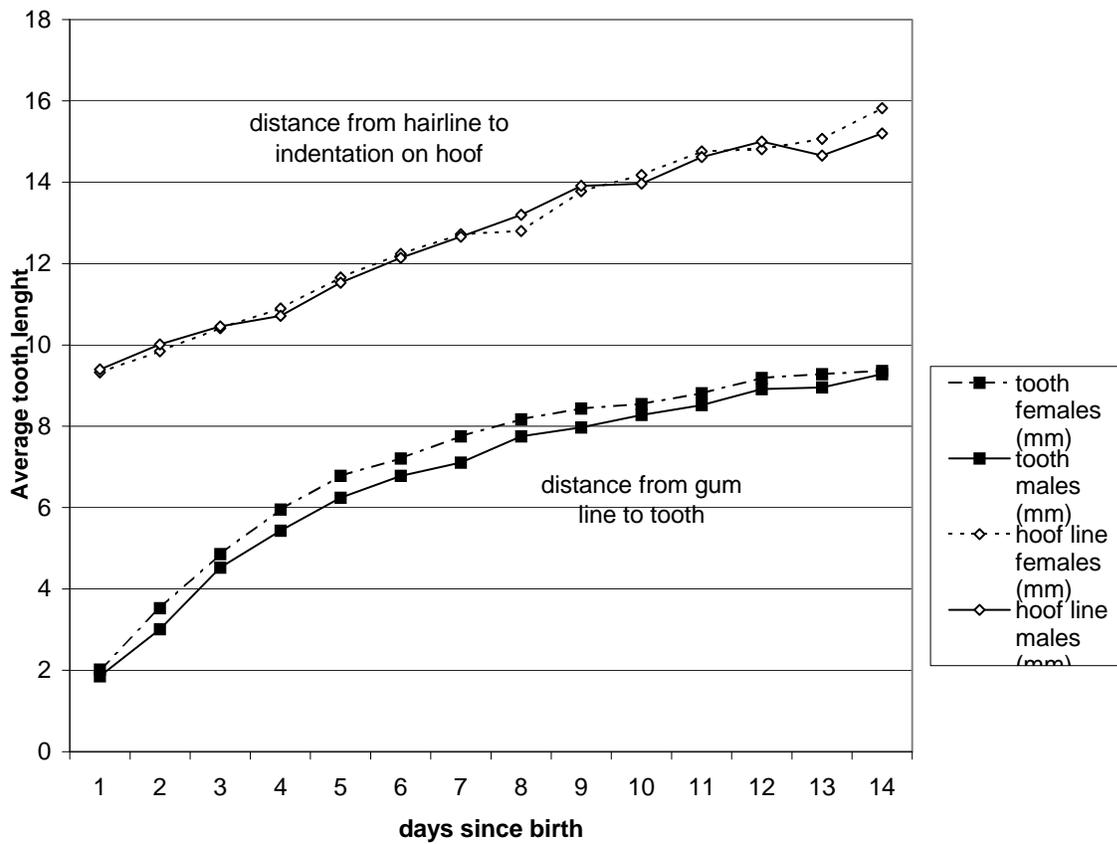


Figure 2. Average tooth length (mid1) and hoof line of Rocky Mountain male and female elk calves at Starkey Experimental Forest and Range, Oregon, 1997-1998.

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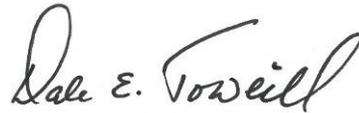
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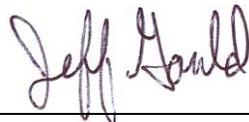
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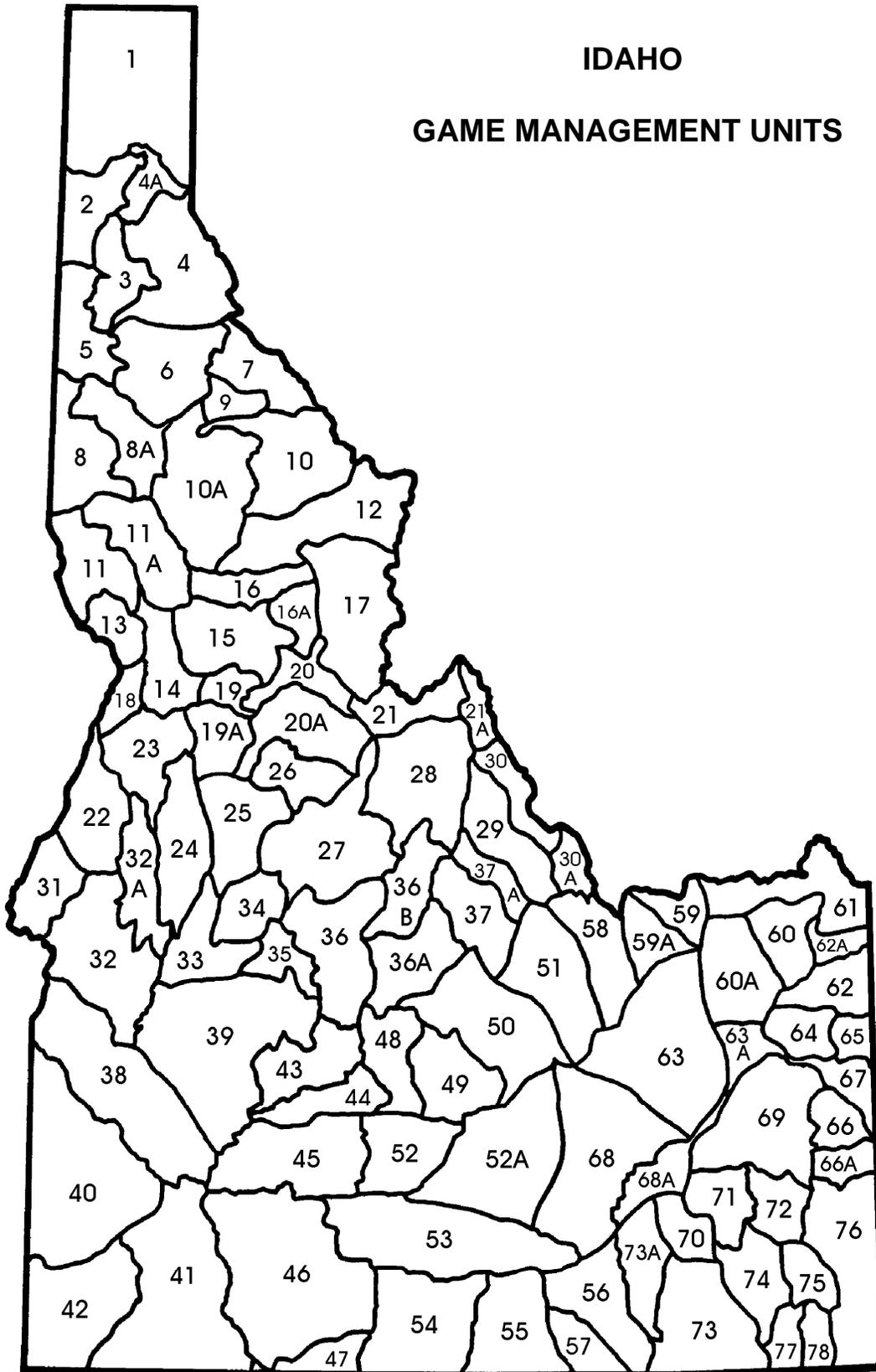


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# IDAHO

## 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.

