IDAHO DEPARTMENT OF FISH AND GAME

Cal Groen, Director

Project W-160-R-35

Progress Report

STATEWIDE HABITAT CHANGE MODELING PROJECT

July 1, 2007 to June 30, 2008

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September 2008
Boise, Idaho

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PROGRESS REPORT
STATEWIDE WILDLIFE RESEARCH

STATE:	Idaho	**JOB TITLE:**	Statewide Habitat Change Modeling Project
PROJECT:	W-160-R-35		
SUBPROJECT:		**STUDY NAME:**	The Effects of Habitat Change on Idaho's Ungulate Populations
STUDY:	I		
JOB:	1		

PERIOD COVERED: July 1, 2007 to June 30, 2008

THE EFFECTS OF HABITAT CHANGE ON IDAHO'S UNGULATE POPULATIONS

Abstract

During 2008, we launched a project designed to determine the efficacy of using satellite imagery to detect and measure habitat change and link that change to ungulate population trends. The initial phase of this analysis includes the collection and correction of Landsat imagery covering three contrasting study areas in Idaho. The second phase will be to establish the appropriate methods of image analysis and statistical modeling to document changes in ungulate habitat. Yearly images from 1989 to 2004 have been selected to represent the peak vegetation growing season with dates ranging from 10 July until 20 August. Vegetation indices will then be applied to determine yearly departures from the average. These departures will then be tested against ungulate population trend data collected during the same time periods.

Introduction

Most wildlife habitat research has focused on habitat use patterns within a small segment of a population of the species of interest. Habitats used by radio-collared animals were measured and described, then compared to habitats that were apparently not used (Irwin and Peek 1983, Edge et al. 1988, Griffith and Peek 1989, Thomas and Irby 1990, Nicholson et al. 1997, Unsworth et al. 1998, Johnson et al. 2000). Such investigations are at the core of our understanding of the relationships between wildlife and their habitats. But to fully understand the dynamics of entire populations and the effects of large scale habitat processes such as wildfire, noxious plant invasion, and changing land use practices, it is important to broaden the temporal and spatial scale of wildlife/habitat investigations. Success in the operation of broad scale studies of ungulate habitat have been a challenge due to the large size of ungulate home ranges. Methods used to conduct broad scale analysis typically involve extensive field work to assess the type and quantity of habitat components within a given area. However, remotely sensed data can also be used to monitor changes in vegetation over a large scale to evaluate wildlife habitat (Kennedy et al. 2007). Remote sensing platforms such as the Landsat Thematic Mapper provide a method of collecting spectral data that can be converted into vegetational indices such as the Normalized Difference Vegetation Index (NDVI). NDVI has been shown to have a strong relationship with above-ground biomass (Rouse et al. 1974, Roy and Ravan 1996). This relationship was used as a proxy for vegetation production in a study by Rasmussen et al. (2006) that demonstrated NDVI

is a stronger predictor than seasonal rainfall of the timing of elephant calving. What this study demonstrates is the merging of remotely sensed data with ecological indicators to infer biological processes. This is a relationship that has not yet been fully explored within the ecological sciences (Hebblewhite et al. 2002). The fundamental role of remotely sensed data in the field of wildlife research has been focused on mapping species habitat and biodiversity (Laperriere et al. 1980, Young et al. 1987, Huber and Casler 1990, Stoms and Estes 1993, Osborne et al. 2001, Scott et al. 2007).

The Idaho Department of Fish and Game (IDFG) initiated this research to address the growing concern regarding changing ungulate habitats within the state. Fire suppression, human encroachment, and noxious weed invasion are just a few of the issues that Idaho's wildlife face (Agee 1998, Pimentel et al. 2005). The impacts of habitat loss and encroachment have been shown for Rocky mountain elk (*Cervus elaphus*) (Czech 1991, Morrison et al. 1995, Unsworth et al. 1998) but have not been as clearly defined for mule deer (*Odocoileus hemionus*). Concurrently, the distribution and size of wildlife populations has also undeniably changed. Elk populations climbed to all-time highs in the 1990s but have declined in certain areas (Figure 1). Unsworth et al. (1999) noted that mule deer populations in the western United States had seen major declines in the late 1960s through the mid 1970s with a recovery about 15 years later. In the 1990s, the population started to decline again which led to much discussion as to the possible causes and solutions (Unsworth et al. 1999).

The management of wildlife populations is a complex task that forces managers to make decisions based on limited knowledge. A manager is able to influence certain aspects of population structure and size by controlling the number of hunters, season length, and hunt type, but they are not currently able to map and quantify habitat conditions (Unsworth et al. 1993). Models are helpful in informing management decisions, but one of the key factors of a model is how easily the input variables are obtained. By showing that NDVI was a better predictor of elephant reproduction than rainfall, Rasmussen et al. (2006) demonstrated that remotely sensed data can be used to provide variables that are easily obtained, have a historical record, and can provide data in areas that might have limited field data. The information provided by this type of analysis should allow researchers and managers to monitor habitat variables on a more frequent and near real-time manner and thusly be able to make more informed management decisions.

Objective

We will (1) collect and correct 15 years worth of Landsat imagery such that the images are radiometrically and geometrically as correct as possible, (2) techniques will be developed and assessed for their ability to measure habitat change at the landscape scale, and (3) relationships will be investigated between the measured habitat change and ungulate population trends.

Study Areas

Idaho has a wide variety of habitat types from high deserts in the southwest to dense closed canopy forests in the north. The selection of the study areas was largely driven by the availability of dependable population surveys. Elk population data has been collected systematically across the state and provides a dataset that can be used with a relatively high degree of confidence. This

made most of the Game Management Units (GMU) that contain elk available for this study. Mule deer surveys were slightly more sporadic which led to the selection of GMU 39 and the combining of GMUs 36 and 36B.

Lolo Study Area

The Lolo Study Area (Figure 2) falls mainly in the Clearwater National Forest and consists of GMUs 10 and 12. It is bordered on the south by Nez Perce National Forest, on the north by the St. Joe National Forest, on the east by the Montana border, and on the west by Dworshak Reservoir. Historically, the vegetation and habitats in this area were shaped by fire (Barrett 1982). In the early 1900s, several major wildfires swept through the area creating large shrub fields and earlier successional habitats. Such habitats were ideal for elk, and the population increased to an estimated 16,119 elk in 1987. The standing vegetation is dominated by mixed mesic forest type species such as western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), and western red cedar (*Thuja plicata*) on the north slopes, while the southern slopes are dominated by more warm mesic shrubs such as alder (*alnus* spp.), red-osier dogwood (*Cornus sericea*), mallow ninebark (*Physocarpus malyaceus*), chokecherry (*Prunus virginiana*), and woods rose (*Rosa woodsii*) (Landscape Dynamics Lab 1999). The area receives an average 101 cm of rain each year with nearly 60% of that falling as 267 cm of snow at Headquarters (Western Regional Climate Center 2008). IDFG's elk sightability model was developed in these GMUs giving this area the longest record of elk surveys in the state. These surveys have revealed that the elk populations in GMUs 10 and 12 have steadily declined since the early 1990s (Figures 3 and 4). Mule deer numbers for these units have been historically low and have not been surveyed.

Boise River Study Area

GMU 39 is the sole unit in the Boise River Study Area (Figure 2). The eastern half of this study area falls within the Boise National Forest while the western half is dominated by the city of Boise and the surrounding agricultural and residential areas. This area has experienced massive losses of treed areas to both wildfire and insect infestation. Roughly 20% of the forest burned between 1986 and 1992. In addition, the tussock moth is credited with defoliating 225,000 acres while bark beetles killed over one half million trees during the same time period (Morelan et al. 1994). These losses have left the area dominated by warm mesic-site shrubs such as alder, ocean-spray (*Holodiscus discolor*), western serviceberry (*Amelanchier alnifolia*), and devil's club (*Oplopanax horridus*), while the burned areas have seen the return of early successional species. Areas in the southwestern portion consist of basin big sagebrush (*Artemisia tridentata* var. *tridentata*), four-wing saltbush (*Atriplex canescens*), and shadscale (*Atriplex confertifolia*) with areas of Douglas fir (Landscape Dynamics Lab 1999). The area receives an average of 60 cm of rain each year and 207 cm of snow at Idaho City (Western Regional Climate Center 2008). While the elk populations appear to be stable or slightly increasing (Figure 5), encroachment from development is diminishing winter range for these animals. This area represents some of the best mule deer survey data within the state of Idaho (Mike Scott, IDFG, personal communication). Radio location data has shown that most of the animals remain in this unit year round (IDFG, unpublished data).

Challis Study Area

GMUs 36 and 36B combine to make the Challis Study Area (Figure 2). Most of this study area falls within the Challis National Forest with a portion occupied by the Sawtooth National Forest in the south. This area is vegetationally diverse with mountain big sagebrush (*Artemisia tridentata* var. *vaseyana*) and basin big sagebrush communities in the eastern portion of the study area and mixed subalpine forest, lodgepole pine (*Pinus contortus*), and whitebark pine (*Pinus albicaulis*) in the eastern and west/southwest portion (Landscape Dynamics Lab 1999). The area receives an average of 33.5 cm of rain each year and 182 cm of snow at Stanley (Western Regional Climate Center 2008). Ungulates in this area typically winter in the eastern portion near the agricultural areas in the lower elevations. During summer, the animals head west into the national forests. Two GMUs were combined so that any animals that were surveyed in GMU 36B during winter would have the appropriate summer habitat change measured in GMU 36. Elk populations have increased in this area (Figures 6 and 7), giving a nice contrast to the stable population in the Boise River Study Area and the declining population in the Lolo Study Area. Mule deer population surveys have taken place in GMU 36B only, but the animals surveyed typically stay within GMU 36 during the summer months (Mark Hurley, IDFG, personal communication).

Methods

The first step in this analysis will include Landsat satellite image collection and correction. A series of corrected, mosaiced, and indexed images will provide the dataset necessary for change detection and analysis. We considered using the Earth Observing System Moderate Resolution Imaging Spectroradiometer for this project. While this system provides more frequent observations, onboard sensor calibration, and atmospherically and topographically corrected data, the major drawback is that it was not launched until 1999. This eliminates its usefulness in this study since we are looking at ungulate population data that extends back to 1989, but suggests its benefits in any future research. Kennedy et al. (2007) credit image misregistration with producing most of the error in their pixel-to-pixel temporal analysis and suggest that time and care be put into any imagery that will be used to conduct that type of analysis. Achieving good results in an efficient manner has become easier with the introduction of automatic point detection software such as IDL ENVI and ITPFIND (Kennedy and Cohen 2003). A set of base images will be corrected manually to then be used with the automated software to correct subsequent imagery. Great attention will be given to geometric correction in an attempt to diminish the effects of misregistration. The next step will be to correct the digital number values from the satellite to actual values representing the amount of electromagnetic radiation collected by the satellite. Song et al. (2001) recommend atmospheric correction for any imagery that will be used for change detection, especially when analyzing large scale landscapes over time. The corrected imagery will then be used to create supplemental datasets that will provide ecological indicators to changes in habitat components.

To quantify the changes in habitat, two different techniques will be used. The first method will use the NDVI as a proxy for above ground biomass (Rouse et al. 1974, Roy and Ravan 1996). NDVI is calculated using the ratio from returned satellite reflectance values between the red visible spectrum and the near-infrared (NIR) spectrum. Actively growing vegetation returns a

higher value in the NIR and a lower value in the visible red creating a high ratio of difference. The NDVI values are represented on a pixel-to-pixel basis which, for the series of Landsat satellites, corresponds to a 30 m X 30 m cell. A mean value will be calculated for each pixel to determine each year's departure from that average. This departure will then be calculated for the entire study area to determine an area's overall trend for that specific year. Different metrics will be calculated for the results of the NDVI images. Metrics such as patch shape, distribution, mean patch size, and mean nearest neighbor will be analyzed along with temporal variables such as onset of growing season, length of growing season, and intensity of peak growing season values.

The second method that will be used involves creating temporal trajectory trend data for each individual pixel. This method was applied by Kennedy et al. (2007) to develop graphical signatures of temporal changes in vegetation structure. Over time, patterns develop that can be linked to either subtle phenomenon like post-fire regeneration or catastrophic events such as the fire itself. While Kennedy et al. (2007) were successful in determining different types of forest manipulation like logging and fire, we will attempt to map areas of habitat loss such as loss of sagebrush steppe. Areas of concern, such as native grasslands lost to invasive weeds, within the study areas will be mapped and their temporal signatures will be analyzed for any patterning that can be interpolated throughout the landscape to map any subsequent areas.

Final analysis will use mule deer and elk population estimates derived from aerial sightability surveys conducted by IDFG. The survey method corrects for animals that were present but not seen due to canopy closure, snow cover, and other biasing events (Samuel et al. 1987). The intrinsic rate of increase or decrease will be calculated for populations within each study area on different temporal scales. A regression tree model will then be created using the developed habitat variables to see if there is a correlation between habitat changes and ungulate population trends. The overall change in NDVI will be compared to the change in respective populations. A time lag will be factored into the regression tree to look for any delayed response between the change in NDVI and a change of the intrinsic rate of increase or decrease within the estimated elk population numbers.

Our projected timetable is as follows:

Spring 2008
- Course work
- Analyze status of imagery
- Obtain GIS layers

Summer 2008
- Develop proposal
- Develop practical methodology for spectrally and geographically correcting imagery
- Create Orthoreferenced Base Layers for future image correction

Fall 2008
- Course work
- Create NDVI Dataset for Lolo Study Area

- Create Temporal Trajectory Dataset for Lolo Study Area
- Develop list of Landsat Scenes for additional study areas

Spring 2009
- Course work
- Acquire and correct images for additional three study areas

Summer 2009
- Create NDVI Datasets for remaining study areas
- Create Temporal Trajectory Datasets for remaining study areas
- Field work: map areas of concern for temporal trajectory analysis

Fall 2009
- Course work
- Analyze NDVI Dataset
- Analyze Temporal Trajectory Dataset

Spring 2010
- Finish writing thesis and journal article(s)

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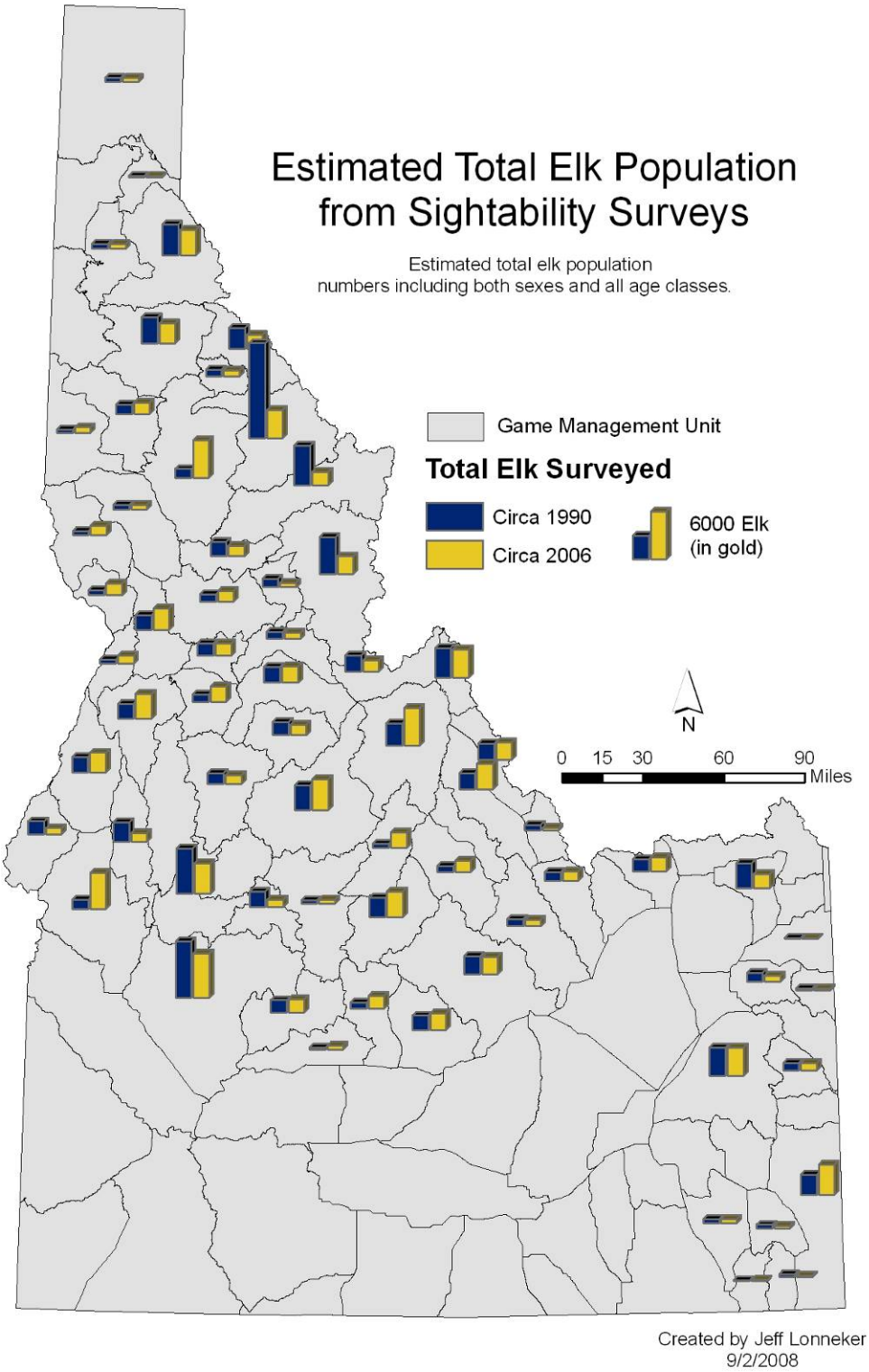


Figure 1. Estimated total elk population from sightability surveys in 1990 and 2006.

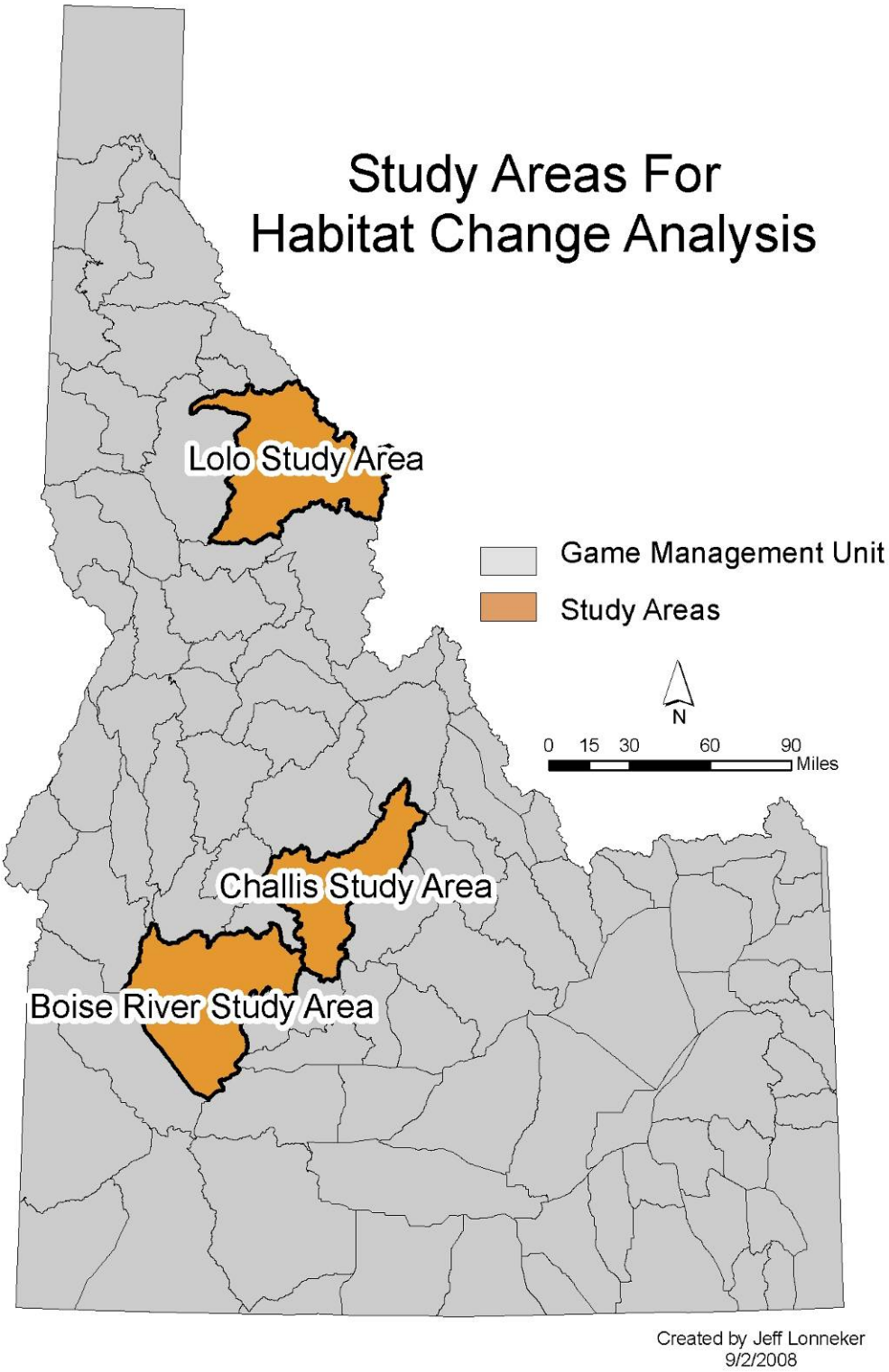
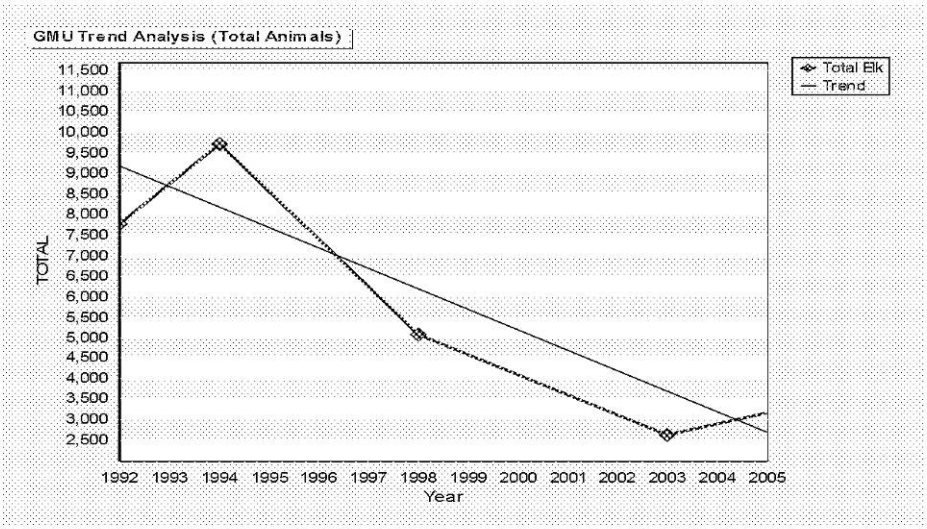
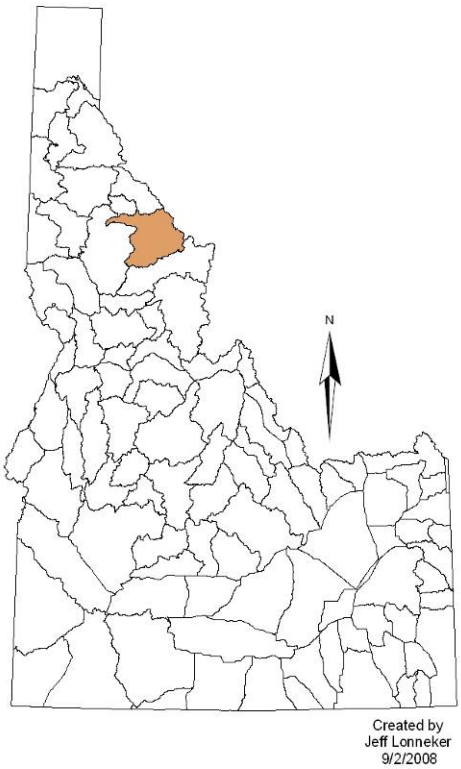
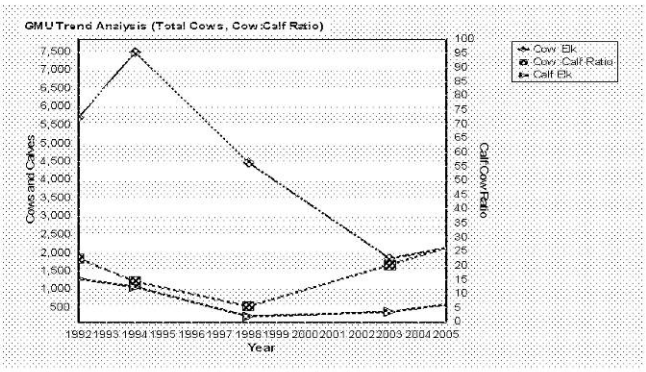


Figure 2. Lolo, Challis, and Boise River Study Areas.

GMU 10 Elk
Population Trend Analysis







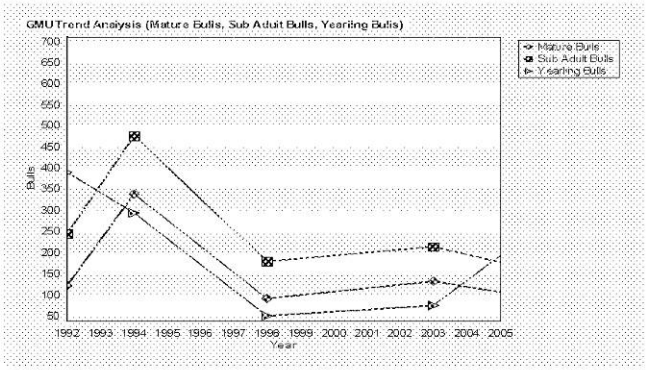
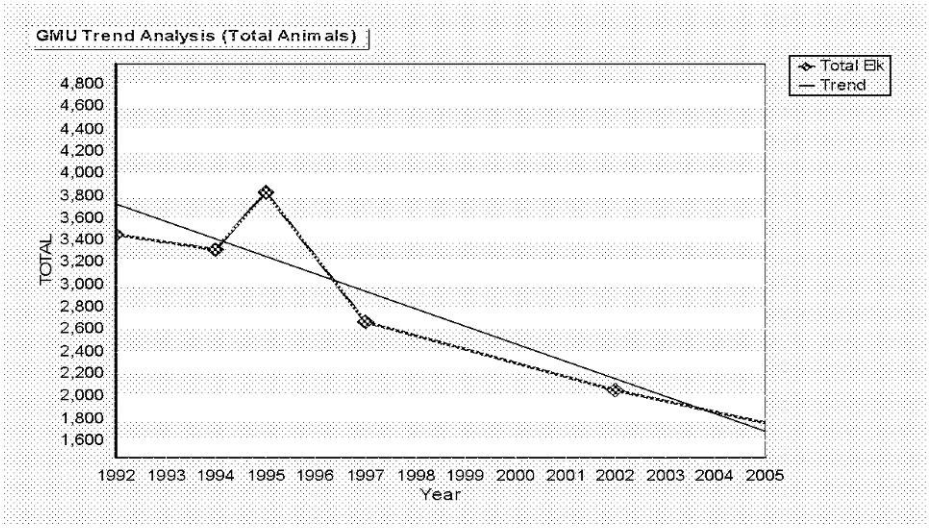
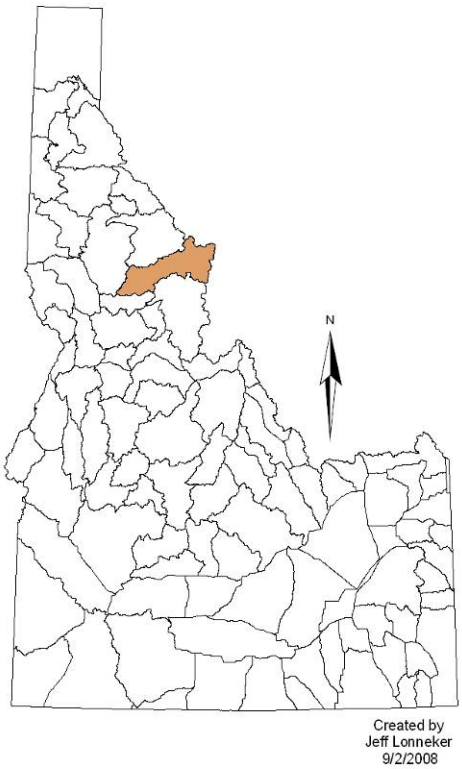
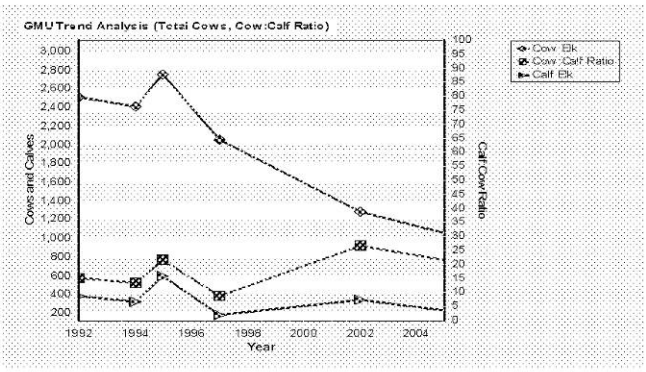


Figure 3. Map and graphs representing the elk population trends within GMU 10.

GMU 12 Elk
Population Trend Analysis







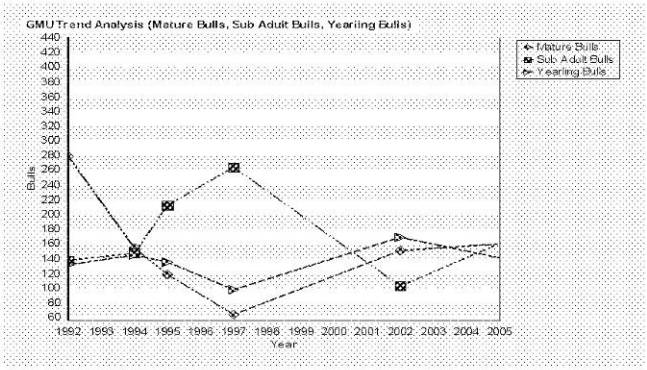
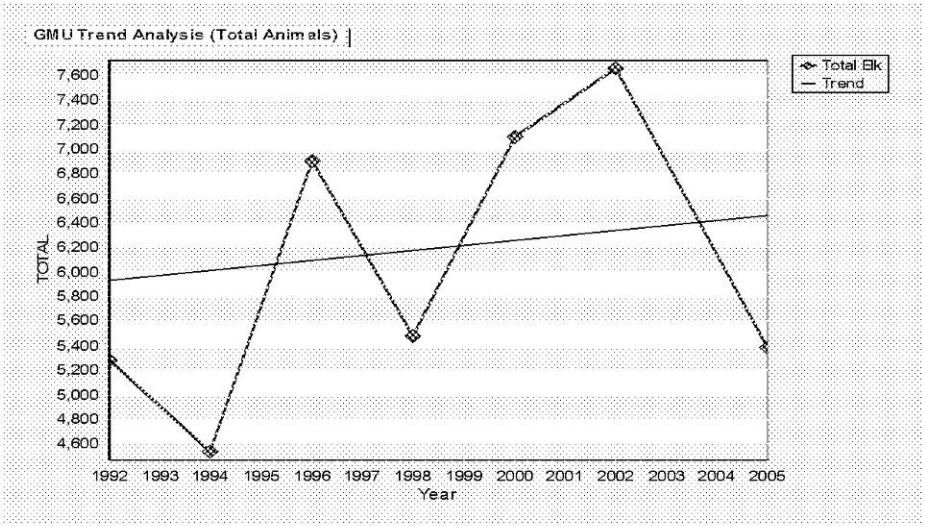
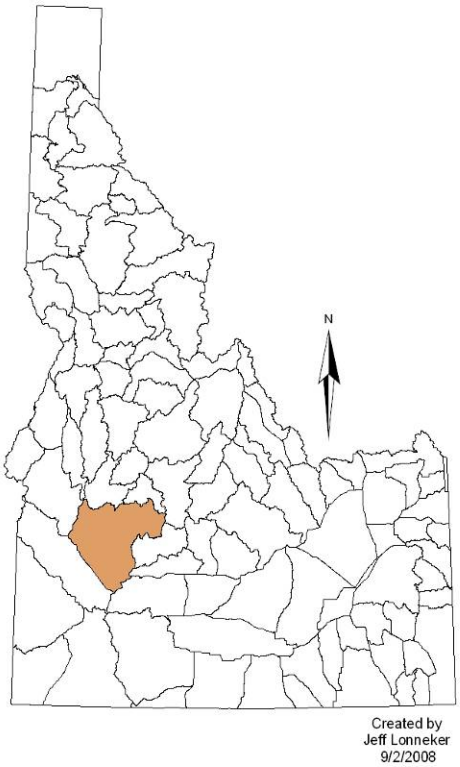
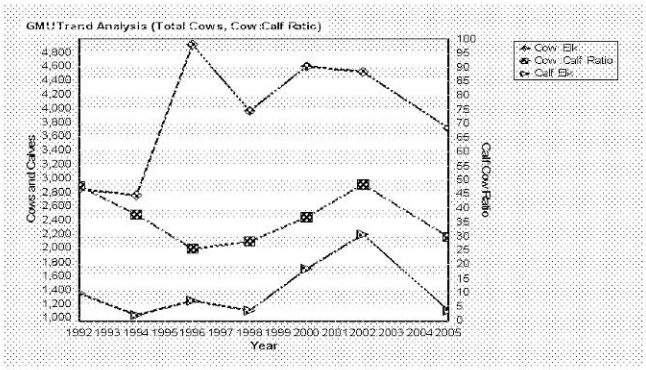


Figure 4. Map and graphs representing the elk population trends within GMU 12.

GMU 39 Elk
Population Trend Analysis







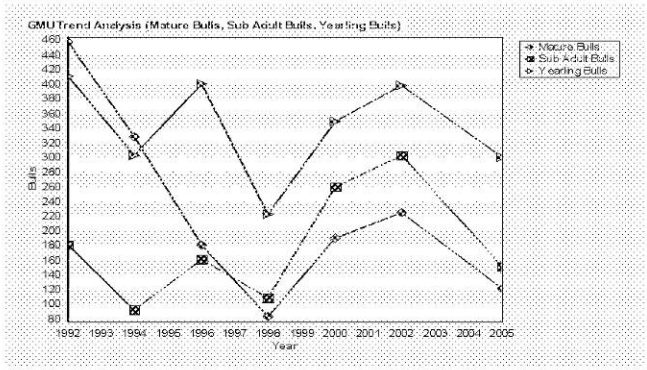
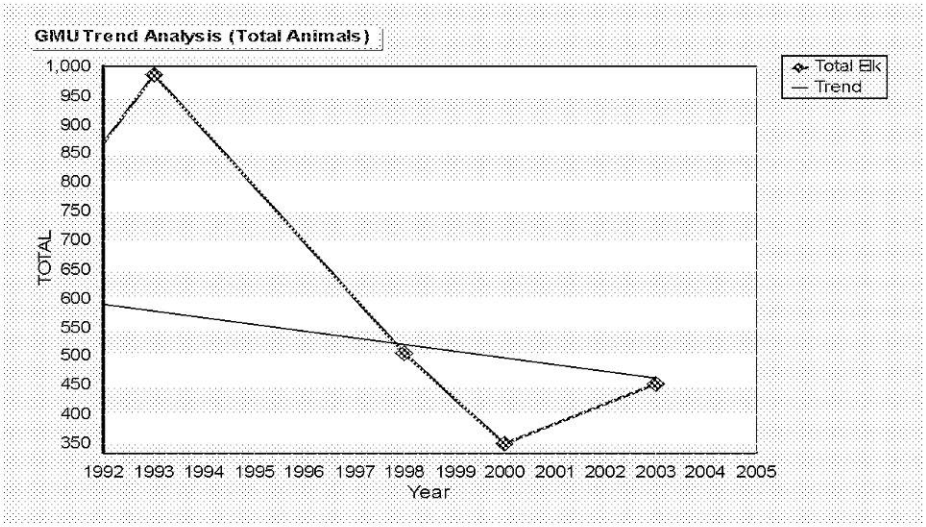
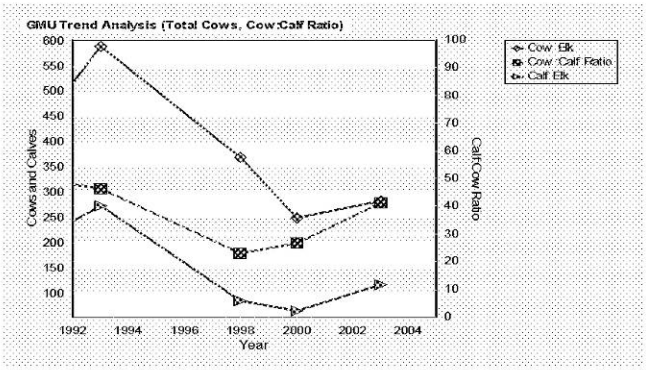


Figure 5. Map and graphs representing the elk population trends within GMU 39.

GMU 36 Elk
Population Trend Analysis





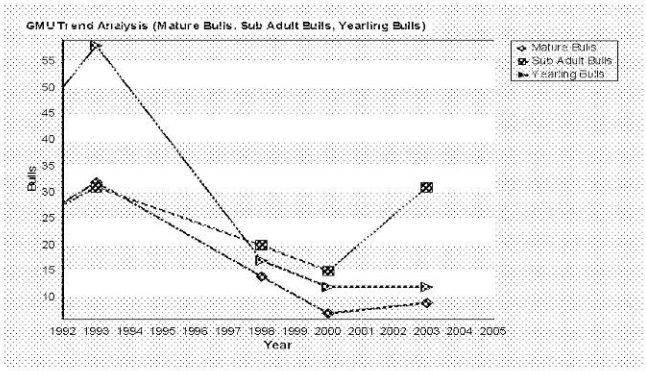
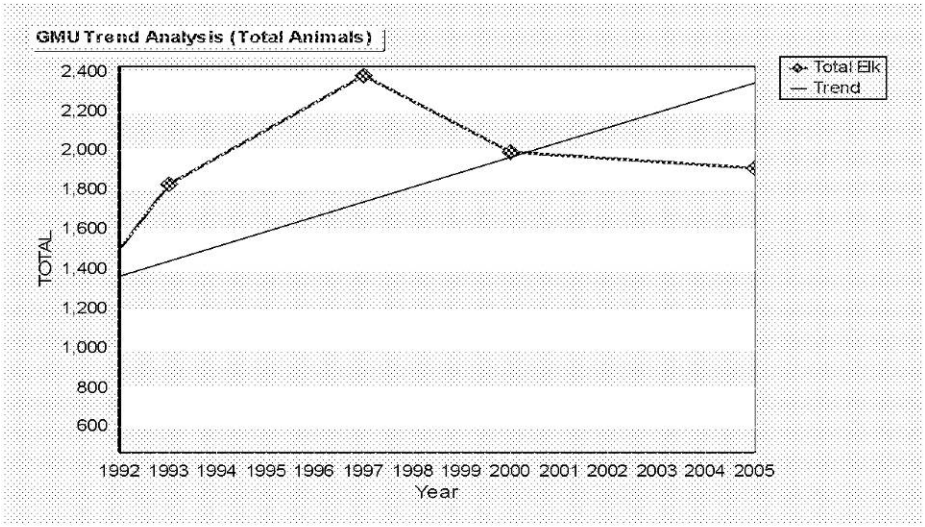
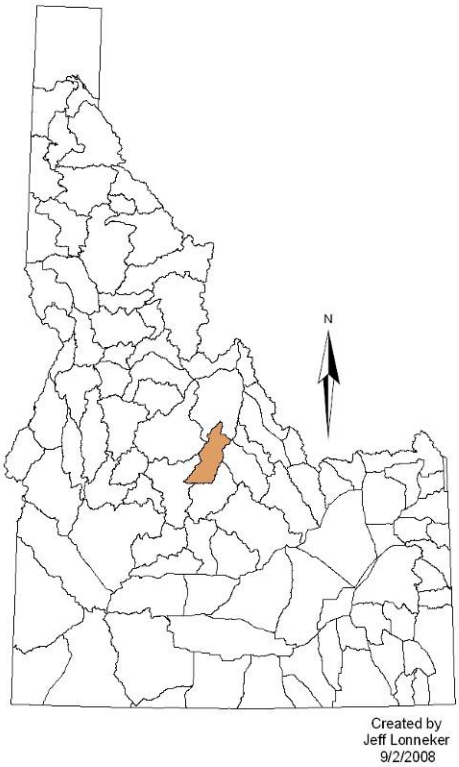
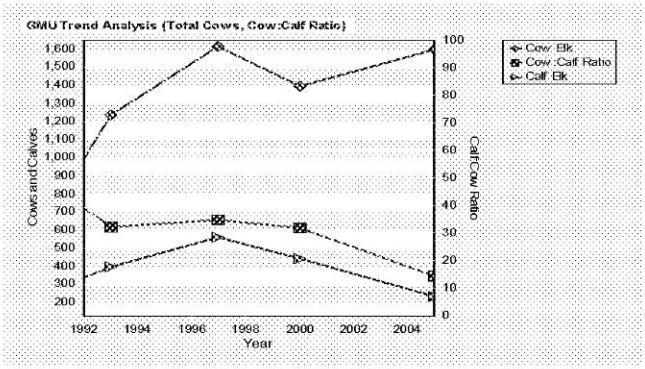


Figure 6. Map and graphs representing the elk population trends within GMU 36.

GMU 36B Elk
Population Trend Analysis







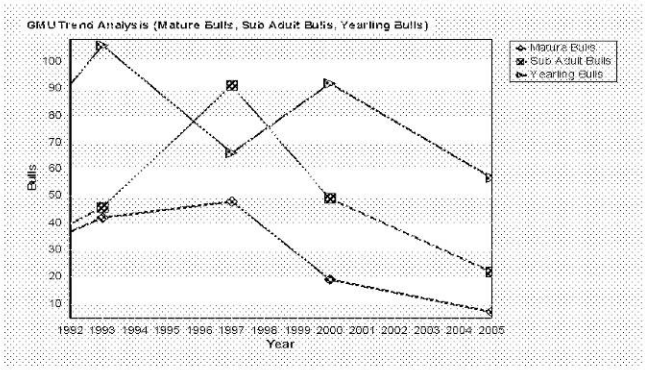


Figure 7. Map and graphs representing the elk population trends within GMU 36B.

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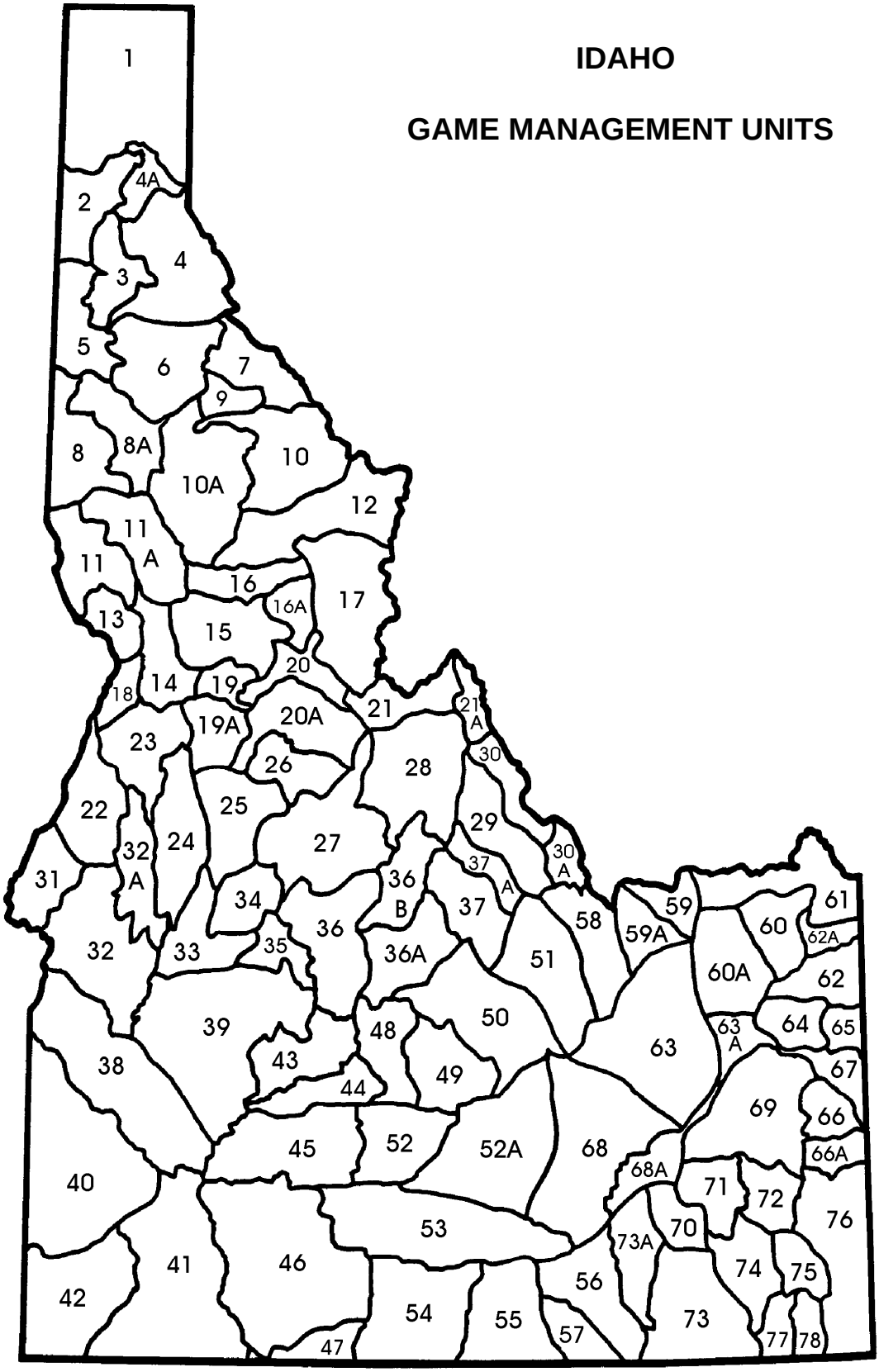
IDAHO

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.