The Habitat Assessment Model:

A Tool to Improve Wildlife Habitat Management

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I. Introduction

Natural resource managers are faced with a complex and dynamic set of challenges. In order to set and meet wildlife population objectives, it is necessary to understand complex habitat relationships and make sound land management decisions. Many ecosystem processes including disturbance, wildlife movement, and nutrient cycling transcend administrative boundaries. As a result, the management actions taken on public lands cannot be separated from the impacts on adjacent private lands and vice versa (Yaffee and Wondolleck 1997). To effectively manage at the ecosystem level it is necessary for public and private land managers to collaborate and discuss management goals for their adjacent lands. Development of common ground and a straightforward decision making framework to facilitate the implementation of sound habitat management practices is critical.

In an effort to resolve fence and forage conflicts on private and public lands, the Colorado Division of Wildlife (CDOW) created the Habitat Partnership Program (HPP). In the winter of 1988-89 concerns over increasing populations of big game and the ensuing fence and forage damages pushed Colorado agricultural groups to propose new legislation to expand CDOW liability for game damages. The two main points of contention were 1) farmers and ranchers were concerned with the ineffectiveness of the Division of Wildlife's Game Damage Program to provide proper and timely compensation for damages and 2) a lack of appropriate landowner input in the development of wildlife herd management objectives. In response, the CDOW director proposed new legislation that eventually led to the formation of the HPP program. Initially created in 1990 as a means to address concerns of big game damage to fence and forage on private lands in Colorado, the HPP has evolved over time. Presently, HPP committees not only resolve fence and forage conflicts, but also focus on habitat improvement projects affecting both private and public lands.

The Habitat Partnership Program was revised and reauthorized in 2001. This new legislation requires that an assessment of the habitat capability be completed. The Habitat Assessment Model has been designed as a tool to aid HPP committees in discerning the relationships between wildlife populations and habitat sustainability. General habitat based management principles have been incorporated into a clear, straightforward model utilizing ArcView GIS technology. This model has been designed to be a transparent, easy to use decision-making tool that incorporates year to year variation in vegetation production and winter severity levels into a modeling scenario. The model includes existing information generated by local, state and federal government agencies as well as critical input from local community members. Every effort has been taken to include local knowledge in the modeling process, thereby strengthening the ties between the model and the real world.

The overall goal of this modeling project is to provide the users with a tool capable of examining the relationships between wildlife population numbers and habitat

sustainability. The Habitat Model produces a range of population values with related management implications that can be used in the DAU planning process.

II. Theoretical Background

A. Habitat Management

Habitat refers to a landscape and an environment suited to meet the needs of a particular species. An **ecological niche** is the space and methods within an ecosystem a species uses to exploit habitat resources to survive and reproduce. Since each species utilizes a different ecological niche, many species coexist within a habitat. The quantity and quality of available resources within a habitat are dynamic and change with many factors including precipitation, disturbance, and grazing. Changes in the supply or quality of resources within a habitat will control the population size that can be supported by that habitat. Many species utilize different habitats throughout the year, and are limited by the habitat that supplies the least amount of a necessary resource relative to their needs. For example, winter range limitations can control elk population size even if spring and summer ranges can support much larger populations.

B. Succession

Frederic Clements first proposed the concept of succession in 1916 as the orderly replacement of one plant community by another in a defined series (Clements 1916). Dyksterhuis further applied this concept to grasslands (Dyksterhuis 1949). This view of succession holds that all rangelands have a single persistent (climax) state in the absence of disturbance, and sites steadily progress from early seral communities to late seral or climax communities.

This idea of succession further held that disturbances drive the system in the opposite direction of the climax state. Therefore, it is theoretically possible to balance the natural progressive tendency to move towards a climax community with grazing pressures that move the community towards earlier seral stages. The magnitude of force acting to move the community towards earlier seral stages would be correlated to stocking rate, with higher stocking rates generating greater retrogressive forces. The result would be a community held in stasis by the balance between grazing intensity and natural successional forces (Westoby et al. 1989).

Although forming the basis for current thought, the view of succession as a linear continuum has lost prominence because too many variables affect plant communities to view succession as a linear process. As a result, Westoby et al. (1989) proposes that a "State and Transition model" is more reflective of the successional process.

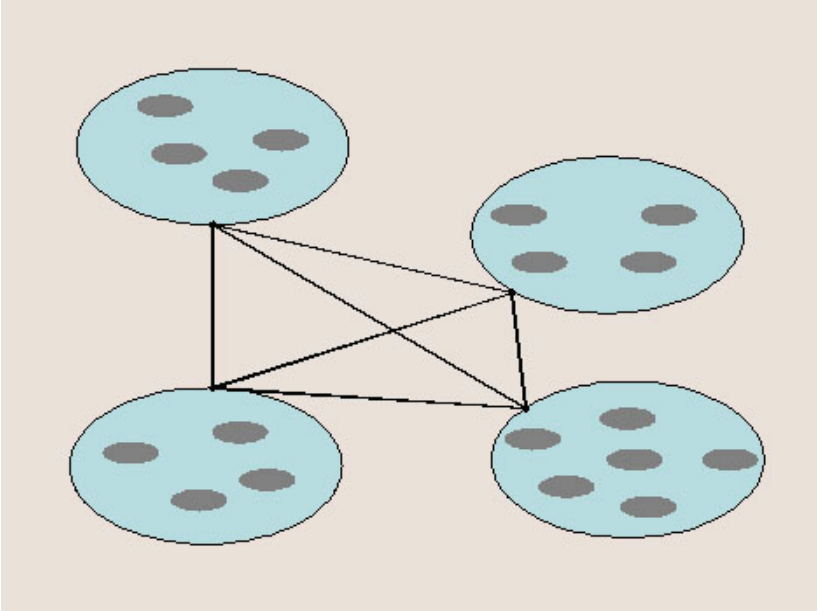


Figure 1. Theoretical Representation of the State and Transition Model- The large light gray circles represent states, the lines between circles represent possible transition pathways, and the small dark gray ovals represent different species compositions within a state.

States, depicted by large gray circles in Figure 1, represent relatively stable, general assemblages of plant species that occupy a site. States are general and can be represented by numerous sets of species assemblages. These different assemblages are characterized by the dark grey gray ovals in Figure 1. It is possible to transition between assemblages while still remaining in the same overall state. Examples of states include annual dominated grasslands, perennial dominated grasslands, and shrublands, while *Stipa comata/Bouteloua gracilis* grassland, *Agropyron spicatum/Agropyron smithii* grassland, and *Artemisia tridentate/Festuca scabrella* shrubland all represent assemblages. Transitions are pathways between states that can be triggered by different actions. These are shown as black lines in Figure 1, and can result from natural events like fire or weather, or by management actions such as changes in stocking rate, burning, fertilization, or the destruction or introduction of species. Transitions may occur abruptly, as with fire, or may occur over extended periods of time. A system does not come to rest halfway through a transition, but always comes to rest within a state (Westoby et al. 1989).

C. Practical Applications

The State and Transition model provides a useful planning tool for managers. After defining the states and transitions within a system, managers can use manipulation tools, such as grazing, burning, or fertilization, to influence transitions into more desirable states. Managers can also recognize when natural climatic conditions combine with other influences, such as grazing, to create a cumulative influence on the vegetation and landscape, and can make management changes to adjust impacts accordingly.

The habitat model provided with this manual allows users to simulate interactions between climate, annual vegetation production, and wild ungulate grazing intensity. By coupling these modeling scenarios with the appropriate understanding of states and transitions for the ecosystems being modeled, predictive results can be made about the interaction of different wild ungulate population levels and their influence on the affected ecosystems. This model should only be viewed as one of many tools that a land manager can use. Public and private land managers still need to constantly appraise the condition of the land and make management decisions on issues such as stocking rates (for both domestic and wild ungulates) and use of disturbance (fire, herbicide, mechanical manipulation) to ensure the land can meet the demands placed upon it without creating long-term degradation. Management decisions need to be reviewed and modified to address the changing conditions generated by changes in weather.

D. Grazing Effects

The defoliation of plants by eating and trampling, redistribution of materials through waste deposition, and general movement patterns of domestic and wild ungulates all influence rangelands. **Defoliation** refers to the removal of physiologically active material, as by herbivore eating, clipping, and trampling (Heady and Child 1994). The affects of defoliation and the plant's response to this event are dependent upon three key variables: frequency of defoliation, intensity of defoliation, and the opportunity for regrowth following a defoliation event. Frequency is a measure of the number of defoliation events during a growing season. Frequency is interrelated with intensity and regrowth opportunity, but generally, increased frequency provides less opportunity for regrowth and can be detrimental to the plant. Grazing intensity represents the proportion of the current year's growth removed by the grazing event. As the amount of plant material removed increases, less leaf area remains for energy capture to fuel regrowth. In severe defoliation, cessation of growth can occur causing the plant to draw on stored reserves. This results in a loss of growth potential for the immediate growing season, and potentially, ensuing seasons as well. The opportunity for regrowth is a function of the seasonality of the defoliation event and it is directly correlated with the relative capability of the plant to achieve a full array of leaves and complete full energy storage each year. Soil water availability and photosynthetic leaf area both play a role in regrowth potential. For example, many grass species are most sensitivity to defoliation when their flowering stalks begin to develop, with sensitivity decreasing rapidly as the plants approach maturity (Heady and Child, 1994). By understanding the interactions of these three variables for controlling the impacts of defoliation, managers can design strategies to minimize the impacts of grazing and use grazing as a habitat management tool (Reed et al. 1999).

E. Comparing Domestic and Wild Ungulate Grazing

Although this model does not directly address the effects of foraging strategy differences between domestic and wild ungulates, it is important to incorporate an understanding of these differences into the decision making process. Archer and Smeins (1991) provide a discussion of some differences between domestic and wild ungulate foraging strategies.

For example, unlike wild herbivores, whose numbers and patterns of distribution can vary annually, domestic livestock concentrations can be artificially maintained at consistently high levels because their stocking rate is controlled by the manager. The use of fences prevents domestic livestock from moving to new areas when the abundance of desirable forage is depleted, which can result in higher frequencies and intensities of defoliation than would occur naturally. Unlike wild ungulates, domestic ungulates can receive the benefit of supplemental feeding when range forage is limited. This supplemental feeding interrupts the natural feedback loop that exists between low forage availability and increased animal mortality and decreased fecundity that helps to limit wild populations when resources are scarce. Although the natural forage limitation feedback loop is interrupted by domestic livestock, the advantage exists that domestic livestock can be removed from the system when forage supplies are exceeded. Wildlife managers can also remove wild ungulates by increasing allowable harvest numbers.

The key concept of this process is that the land has a finite and limited capability to provide forage for a mixed group of grazers. When that limit is reached or exceeded, there are ecological and animal performance consequences. The greatest dependability and the lowest risk of negative ecological and animal performance occur at moderate stocking rates that fall well below the threshold of maximum capacity. This relationship reflects year to year variability in forage availability and forage quality, as well as variability in determining reliable estimates of actual grazing animal populations.

The focus of the Habitat Model is to take many of the concepts just discussed and incorporate them into a simple model. This task is difficult, and an understanding of the theoretical background of the model will allow the user to more accurately assess the implications of the Habitat Model results. The data used in the Habitat Model also forms a critical component, and Section III provides a review of the methods used in the data gathering process.

III. Data Input Sources for the Habitat Model

Gathering and processing information to generate the Habitat Model is one of the more difficult steps in the modeling process. Data sources need to be gathered, interpreted, manipulated and properly formatted and some new data has to be generated. This section will outline data needs and suggest sources and methods for collecting the necessary data using the North Park case study. In the appendices, specific data and methods used in each area example are presented. There are four general areas in which data is needed. These are:

A. Vegetation Production Values
B. Wildlife Winter Range Polygons
C. Additional Wild Ungulate Offtake from Non-Target Species Other Than Elk and Mule Deer
D. Livestock Offtake

Each of these will be addressed below.

A. Production Values

Production values are critical to the model since they determine the quantity of forage available for consumption by both domestic and wild ungulates. A number of different vegetation coverages exist, but in order to be useful, there must be a production value associated with the vegetation type. The three most available data sources from general to specific are:

1. **State Soil Survey Geographic Database (STATSGO) -** Soil maps for the STATSGO database are produced by the USDA-NRCS Soil Survey Division, and are derived by generalizing detailed soil survey data. STATSGO maps use a scale of 1:250,000 (with the exception of Alaska, which is 1:1,000,000). To generate these maps, the entire map area is divided into a number of polygons representing the underlying soil types. Each soil type is associated with a broad range-site type and a production value for that range site. These range-site types and production values are based on sampling from representative sites in good condition. It may be necessary to modify these production values to more accurately reflect local conditions. These modifications should be made by someone with knowledge and expertise in the range evaluation field. To use this data, competency in importing and manipulating data in ArcView and Microsoft Excel or Microsoft Access is necessary. As of May 2005, the citation and source for STATSGO data is: U.S. Department of Agriculture, Natural Resource Conservation Service. "State Soil Geographic (STATSGO) data base for Colorado." 1994. http://www.ncgc.nrcs.usda.gov/products/datasets/statsgo/data/co.html

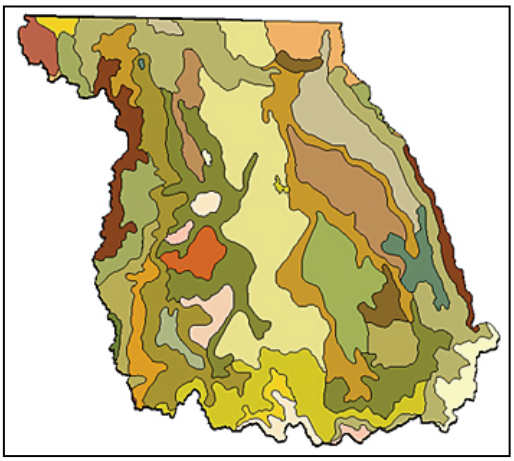


Figure 2. Example of a STATSGO coverage.

2. **Soil Survey Geographic Database (SSURGO)-** The information contained within this database is similar in structure to that of STATSGO, however, this data is formed from the county level soil survey. One result of this is that many of the soils that were aggregated to form one soil polygon at the STATSGO level are now divided into numerous soil polygons, thereby increasing the complexity of the soils map. This serves to increase the resolution of the range site production estimates and may increase the accuracy of the production estimates at smaller geographic scales. SSURGO data is currently not available for all areas within the U.S. The USDA-NRCS is in the process of updating this information, but it is a time consuming task. Similar to STATSGO, range-site types and production values are based on sampling from representative sites in good seral condition. It may be necessary to modify these production values to more accurately reflect local conditions. An understanding of Arcview and Microsoft Excel or Microsoft Access is necessary to process the data. As of May 2005, the citation and source for SSURGO data is:
U.S. Department of Agriculture, Natural Resources Conservation Service. "National Map Unit Interpretation Record (MUIR) Database". 1994. Fort Worth, Texas.
http://soildatamart.nrcs.usda.gov/

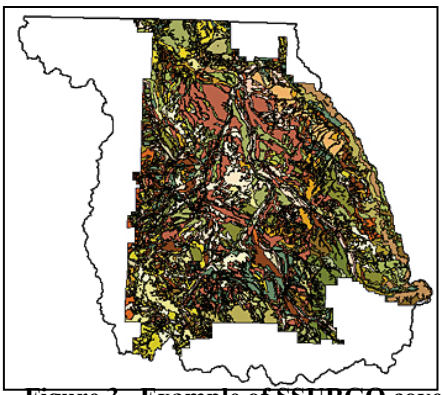


Figure 3. Example of SSURGO coverage.

3. **Local Data Sources-** The model building process requires a collaborative effort, utilizing the resources available from individuals on the HPP committee whenever possible. In some cases, government agencies or local groups may have production information that is more accurate and site specific than the information contained in either STATSGO or SSURGO. These data sources should be reviewed and used if they can be modified and imported in a time and cost effective manner. At the least, it may be possible to modify the range site production values contained in the STATSGO and SSURGO databases to more accurately reflect local conditions. Local cooperators are usually the most accurate source of information regarding livestock numbers and animal distribution information. However, caution should be taken not to overextend the scope of local data. For example, production information collected on a single allotment may not be appropriate to use as the basis for production estimates for all the allotments within a county.

Climatic variability plays a key role in determining production values. A study in northwestern Colorado showed that 70 percent of the variability in annual net primary production (ANPP) was the result of climatic variability (Hobbs et al. 1996). To capture this variability in the Habitat Model, representative values for years of low, average, and high annual net primary production are necessary. Regardless of data source, all production values used in the Habitat Model should be standardized to the following descriptions from the USDA-NRCS (U.S. Department of Agriculture, Natural Resources Conservation Service (1994):

1. **Below Average Production-** The estimated annual potential production of range forage for the soil in a year of unfavorable or below average growing conditions, rounded to the nearest 100 pounds.
2. **Average Production-** The estimated annual potential production of range forage for the soil in a year with normal or average growing conditions, rounded to the nearest 100 pounds.
3. **Above Average Production-** The estimated annual potential production of range forage for the soil in a year with above average growing conditions, rounded to the nearest 100 pounds.

B. Winter Range Polygons

Winter range polygons predict the distribution of wild herbivores across the landscape based on the severity of winter conditions. These winter range polygons are used to determine the amount of forage available to wintering populations of elk and mule deer (moose and pronghorn will be discussed later). The Habitat Model uses a combined winter range distribution for elk and mule deer. Four winter range distributions for elk and mule deer are used to build the Habitat Model in the North Park Study Area. (In other study areas, additional polygons are used.) These distributions are:

1. **Average Winter Range-County** - That part of the overall range where 90 percent of the individuals are located during the average five winters out of ten from the first heavy snowfall to spring green-up, or during a site specific period of winter as defined for each DAU.
2. **Severe Winter Range-County -** That part of the overall range where 90 percent of the individuals are located when the annual snowpack is at its maximum and/or temperatures are at a minimum in the two worst winters out of ten.
3. **ANWR Entire Subherd -** A boundary defined by the HPP committee that represents the area utilized by a distinct subherd of the overall elk and mule deer population around the Arapahoe National Wildlife Refuge. This study unit was created as a secondary area of interest to the HPP committee.
4. **ANWR Boundary -** Represents only those lands which fall within the administrative boundary of ANWR. This area of study was designated an area of interest by the HPP committee.

The DOW currently collects and maintains some of this distribution data for many wildlife game species in Colorado. This data set resides under the Wildlife Resource Information System (WRIS) established by the CDOW in 1974 and is available online from the CDOW Natural Diversity Information Source (NDIS) website. However, this data set should not be used for elk and mule deer in the Habitat Model if not up-to-date. To ensure the winter range distributions accurately reflect current conditions, and to include input from all HPP committee members on the winter range polygons, re-mapping of winter range polygons may occur using SMART Board technology. The DOW GIS team currently uses this technology to update WRIS data sets and it has proven effective in the Habitat Model pilot study. Using this technology, field personnel edit/enter map features directly into a Geographic Information System (GIS) by simply drawing on base maps projected onto an interactive whiteboard. With the assistance of the GIS specialist, there is no need for the field personnel to have prior GIS experience. Map layers can be panned, zoomed and queried to assist the managers as they draw habitat boundaries on the whiteboard (Cowardin and Flenner 2003). The equipment for this process consists of a laptop, computer projector, external storage drive and a 60-inch interactive SMART Board with a floor stand and carrying case. The mapping process is as follows:

1. The DWM and the GIS specialist review the current WRIS maps and make any changes necessary to reflect current winter range distributions. Only the DWM is included during the initial modification of the data to streamline the initial editing process.
2. After the DWM completes the initial editing process, the entire HPP committee reviews the winter range distributions. During this time, the entire committee should thoroughly review the distributions and discuss any issues that arise. Changes should be made based on committee member input, and the distributions should be finalized.

3. The entire committee should now agree on the validity of the winter range polygons.

Figure 4. SMART Board Mapping Process.

After the mapping process is complete the modeler must then import the polygons into ArcView and edit them into the proper format. For the Habitat Model the distributions of elk and mule deer are combined to create one set of mild, average, and severe winter range polygons for both elk and mule deer (Figure 5).

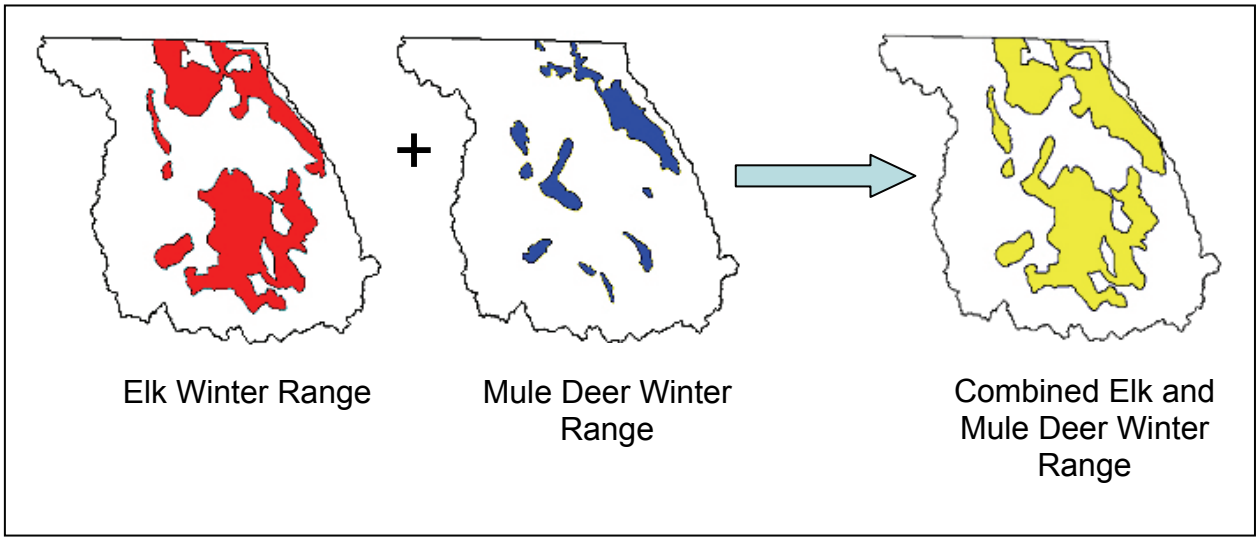


Figure 5. Creation of Winter Range Polygons. The winter range for elk is combined with the winter range for mule deer to generate a combined winter range polygon used in the Habitat Model.

C. Non-Target Wild Ungulate Offtake

In most areas there are going to be wild ungulates other than mule deer and elk consuming forage. To include these animals in the Habitat Model, an offtake map accounting for their forage use is generated. The WRIS data mentioned before should contain digital maps detailing the overall range and winter range for all species which fall into this category and are relevant to the scope of this modeling process. These WRIS maps, combined with estimates of current population numbers provided by the DOW, are

used to generate forage offtake maps for these species. The process for generating offtake maps for one of these species is as follows:

1. Obtain the WRIS digital maps (shapefiles) of overall range and winter range for each species from the Natural Diversity Information Source (NDIS) website (http://www.ndis.nrel.colostate.edu) or by contacting the DOW GIS Unit.
2. Get an estimate of current population numbers from the DWM or from the Habitat Biologist responsible for that area.
3. Calculate the total forage demand generated by the estimated population. Figure 6 provides the average body weight estimates for the wild ungulate species used in the Habitat Model. Average daily forage demand for grazing ungulates varies from 2.5 percent of body weight during active forage growth to 1.5 percent during forage dormancy (Holechek and Pieper 1992). To account for this range, 2 percent of the average body weight of an individual animal per day is used in the Habitat Model. See Figure 7 for an example of this calculation.

Wild Ungulate	Average Body Weight per Individual
Pronghorn Antelope	100 lbs
Moose	1000 lbs
Elk	500 lbs
Mule Deer	150 lbs

Figure 6. Sample Average Body Weights for Wild Ungulates Used in the Habitat Model- Average weight for all individuals within a population. Estimates based on information from Wassink (1993).

4. The forage demand generated in step 3 now needs to be allocated across the landscape. To do this the demand created by the entire population is distributed equally across all of the land within the overall range for 6 months and then across only the land in the winter range for six months. For example, using Figure 6, the demand on the overall range from our pronghorn population would be 91,250 lbs (representing 6 months of demand), and the demand on the winter range would be 91,250 lbs (also representing 6 months of demand).
5. Once the forage demand for the overall range and the winter range has been calculated, the information needs to be converted into an offtake grid (a type of digital surface map). To accomplish this, the modeler needs to determine the total area within the overall range and the winter range, respectively. The total area for each range is then divided by the total demand in pounds per acre to generate a pounds per acre offtake value. For example, let us assume that the overall range is 50,000 acres and the winter range is 25,000 acres. Based on our example above that would be 1.82 lbs/acre (91,250 lbs ÷ 50,000 acres) for the overall range and 3.64 lbs/acre (91,250 lbs ÷ 25,000 acres) for the winter range. Notice the offtake demand on the winter range is higher because the same amount of forage demand is placed on a smaller geographic area.

6. Once the pounds per acre offtake value has been determined, the modeler now converts the overall range and winter range shapefiles into one-acre grids, with each grid cell containing the appropriate offtake value. Based on our example, the overall range offtake grid cell would have a value of 1.82 and the winter range value would be 3.64, respectively. These grids are then used by the model in the calculation of the population of elk and mule deer that can be supported.
7. This process should be repeated for each additional wild ungulate (other than mule deer and elk) that is in the Habitat Model.

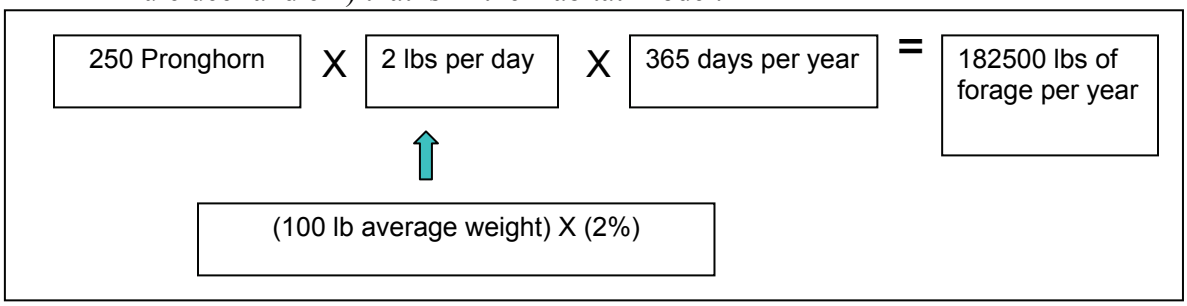


Figure 7. Example of Forage Demand Calculation for Additional Wild Ungulates. This is a theoretical example of the calculation used to determine the forage demand for 250 pronghorn antelope over the course of one year. The number of individuals in the population is multiplied by the forage demand per day. This total, representing the daily forage demand for 250 pronghorn, is multiplied by the number of days in one year to generate the total annual forage demand.

D. Livestock Offtake

Since livestock and wildlife can utilize the same areas for forage, livestock offtake needs to be included in the Habitat Model. Trying to accurately determine livestock offtake can be a difficult task since many ranching operations utilize both private and public lands at varying intensities throughout the year. The level of detail that can be captured in the modeling process results from a balance between the information available and the time-cost constraints of processing data. At the scale of resolution for the Habitat Model, the livestock offtake issue can be summed into two questions: (1)How many animals? (2)Where are they grazing? For the reasons outlined above, the process of gathering livestock offtake information will likely be unique in each modeling situation. Described below, in order from general to specific, are three possible methods for collecting this information. The Habitat Model assumes each Animal Unit Month (AUM) is equivalent to 800 pounds of forage demand. The case studies in each appendix review a real world approach to this issue.

1. Determine the total number of livestock AUMs for the area being modeled, and then distribute the AUMs evenly across the entire area. Landowners and others on the HPP committee may be able to provide an estimate for livestock use. Colorado Agricultural Statistics can also provide a reasonable, general source of livestock numbers at the county level. If Colorado Agricultural Statistics must be used, consult the landowners and others on the HPP committee to ensure the numbers provided are a plausible estimate. This estimate can then be used to generate an offtake grid similar to that described for wild ungulate offtake. To create this grid the total demand generated by the AUMs would be divided by

the total land area, resulting in a fixed number of pounds per acre being removed across the entire area being modeled.

2. Determine the total number of livestock AUMs for the area being modeled and then ask the committee to distribute the animals across the landscape. Using this method, committee members would divide the area into a number of smaller subunits. AUMs would be distributed into these subunits based on information from the committee, resulting in varying levels of forage offtake across the area being modeled. This method provides a more detailed picture of livestock offtake because it distributes grazing pressure in a more realistic manner across the landscape. An example of this method is provided in the case study in Appendix 1.
3. Utilize localized livestock grazing data and offtake maps provided by government agencies combined with utilization information from local landowners. Although this method may provide the most accurate livestock offtake information, it is the most difficult and time consuming to collect. Much of the information provided by the agencies must be manipulated into a usable GIS format, and many landowners may not be willing to provide this information. This method would be most useful when dealing with a few, willing landowners and government agencies that already have grazing information in a usable format.
4. Gather livestock numbers from Colorado Agricultural Statistics, and then distribute those AUMs across the landscape by using remote imagery to predict stocking rates. Satellite images of the 'greenness index' of the landscape can be, and have been, used throughout the world to predict livestock stocking rates. An example of this method is provided in the case study in Appendix 3.

Each modeling effort will be different, and the method used to gather livestock offtake information will be dictated by the situation. It may be necessary to use a combination of the methods described above. The overall goal is to try and obtain the most realistic distribution of livestock offtake possible in the most efficient manner.

IV. Model Design

The habitat model was designed to be a simple, transparent tool to facilitate the implementation of sound habitat management practices. Wildlife population management decisions have typically been based on population models. These population models often incorporate minimal information regarding the feedbacks that exist between herbivory and vegetation (Weisberg et al. 2002). This model uses simple forage accounting theory, and all calculations rely on simple arithmetic. The following figure depicts the logic used in the model design.

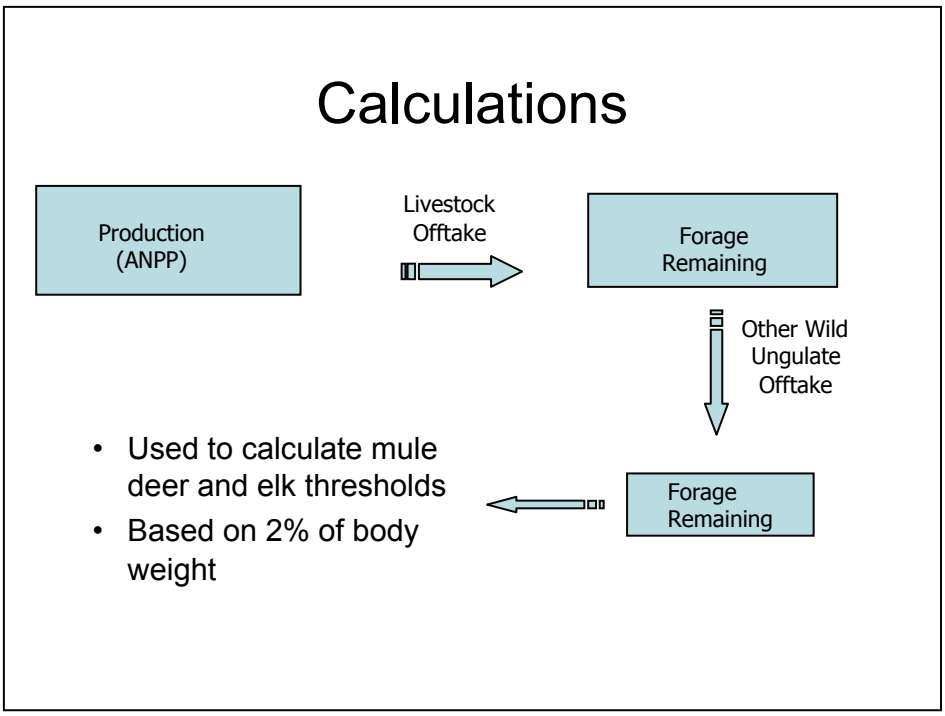


Figure 8. Logic Used to Create the Habitat Model- This simple diagram reflects the steps used in the Habitat Model to allocate available forage and predict the elk and mule deer populations that can be supported on the remaining forage base.

The previous section describes how the information relevant to each of the boxes and processes in Figure 8 is collected. The information in Figure 8 is then used in the following manner to create mule deer and elk population estimates. First, the values contained in the livestock offtake grid are subtracted from the ANPP production values for each grid cell. This step represents the removal of forage by grazing livestock. Next, the grid representing the demand from wild ungulates, other than mule deer and elk, is subtracted from the remaining forage base. The population of elk and mule deer is then based on the forage remaining in each grid cell. The Habitat Model is written with the intention that all mule deer and elk within the population predicted by the model results are allocated forage equivalent to 2 percent of their body weight per day. This ensures continued adequate performance of the projected population. The forage calculations are based on an average body weight of 150 pounds for each mule deer and 500 pounds for each elk.

V. The Use of Thresholds

A threshold represents a theoretical level at which any further stimulus will result in a response from the system. In this case, **level** refers to forage removal by grazing, while **further stimulus** equates to additional grazing pressure, and **response** represents a change in the system.

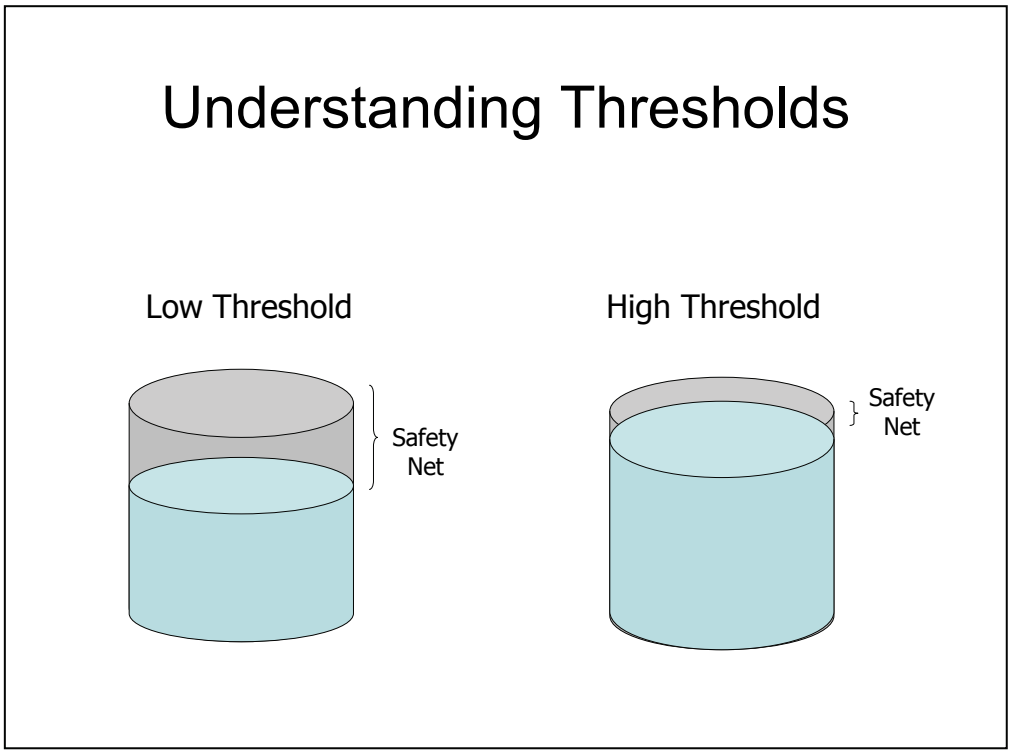


Figure 9. Understanding Thresholds- The cylinders represent the ability of the habitat to deal with stress. The light gray portion represents the stress to the system caused by the grazing the Habitat Model allows while the dark gray portion represents the remaining flexibility in the system to deal with additional stresses (climate, invasive species, pests, additional use).

The Habitat Model calculates the forage available to mule deer and elk at a low threshold level, midpoint, and a high threshold level. Figure 9 provides a theoretical depiction of the relationship between the two threshold endpoints. Grazing is generally agreed to be a stressor in most systems. The low threshold represents light to moderate grazing, which should leave ample resources within the system to deal with stressors such as drought, pest infestation, or any others that may occur. This ability to deal with additional stressors is represented by the **safety net** depicted in Figure 9. The high threshold represents more intensive grazing, while theoretically, not exceeding the capacity of the system to deal with grazing stress. However, as Figure 9 shows, there is a much smaller **safety net** at the high threshold, representing a decrease in ability of the system to deal with unforeseen stressors. Both the low threshold and high threshold have their advantages and disadvantages for the habitat and livestock, and the elk and mule deer populations. An overview of these will be provided below.

A. Defining the Threshold Values

Many factors combine to determine the threshold of herbage consumption for an individual community. These factors include species composition, season of use, intensity of use and prior grazing history. The threshold levels used in the Habitat Model are based on the union of practical field knowledge and review of previous work. A number of studies have been performed to assess the effects of grazing on grassland and shrublands from various parts of the world. A review conducted by Milchunas and Lauenroth (1993) compiled 97 of these studies encompassing 276 data sets, and generated some general results for herbage consumption. In semiarid systems with a short evolutionary history of grazing, when grazed versus ungrazed plots were compared, there was a mean consumption rate of aboveground net primary production (ANPP) of 35 percent in the grazed plots. This consumption rate resulted in a moderate change in species composition from native vegetation. Holechek and Pieper (1992) show moderate grazing intensity for different semiarid range sites varies from 25 to 50 percent, with moderate grazing for sagebrush grasslands averaging between 30 and 40 percent ANPP, depending on condition.

Unlike most grazing studies that focus on the pasture or allotment scale, the threshold levels used in the Habitat Model apply to an entire landscape, and encompass numerous range-site types. For the Habitat Model, we created these numbers based on the research above and the need to distribute use across the entire landscape. The low threshold value represents the consumption of 25 percent of the total ANPP, midpoint consumption equals 28.5 percent, and the high threshold value equates to 32 percent consumption of ANPP. These thresholds are based on forage use averaged across the entire landscape. Some areas within the landscape being modeled will receive use above the threshold levels, while others will receive little or no use. The assumption within the model is that these thresholds represent sustainable usage levels based on the scale of an entire landscape. Periodic field monitoring and management actions by trained personnel will be necessary to ensure habitat sustainability in heavily used areas.

B. Low and High Thresholds Effects on Habitat

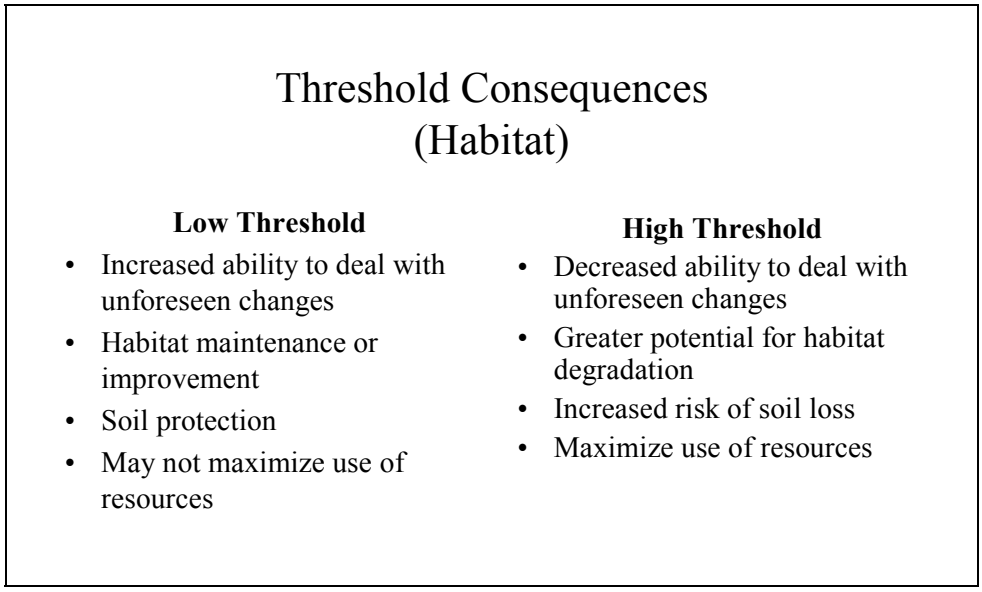


Figure 10. Threshold Consequences Relating to Habitat

Figure 10 provides a comparison of some of the habitat consequences related to managing at either the low or high threshold levels. At the low threshold level, a habitat has an increased ability to deal with additional stressors, and a greater chance for maintenance or improvement of habitat condition. The additional ground cover provided by the increased aboveground biomass at the low threshold level as compared to the high threshold serves to protect the soil from erosion. The greatest advantage to managing near the high threshold is that a greater portion of the forage resources within the system will be utilized by livestock and wildlife.

C. Low and High Threshold Effects on Wildlife

Choosing to manage at either the low or high threshold has an impact on the performance of the elk and mule deer populations as well. Figure 11 provides a comparison.

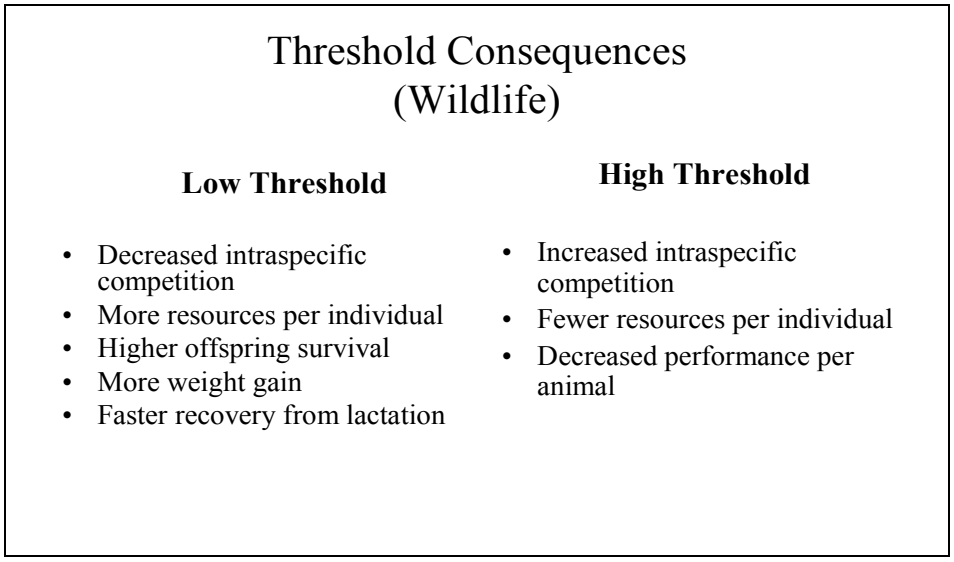


Figure 11. **Threshold Consequences Relating to Wildlife**

The low threshold provides decreased competition between individuals resulting in more resources being available to each animal within the population. In theory and practice, this leads to increased fecundity rates, greater weight gains per individual and decreased recovery time following lactation. All of these lead to an overall healthier population. The obvious downside to operating at the low threshold is that there are fewer overall individuals within the total population. Essentially, the choice between managing at a low threshold versus a high threshold represents a tradeoff between individual performance and total number of individuals within a population.

The threshold discussion to this point has focused on comparing low threshold consequences to high threshold consequences. The low and high thresholds simply represent theoretical lower and upper limits that can be used by HPP committees to make management decisions. Population goals for trophy management are different from those promoting maximum harvest numbers. Erratic weather patterns also affect population management objectives. These thresholds only serve as guidelines. Ultimately, each committee will have to choose population levels based on their long term goals.

VI. Loading the Habitat Model

The directions that follow inform the user on the installation process for the **Habitat Assessment Model.** It is assumed the user already has some familiarity with Windows™ and ESRI ArcView™ software.

1. Create a new folder on your hard drive called **Habitat_Assessment_Model** (Be sure to include the underscores in the folder name in place of spaces).
2. Insert the Compact Disc (CD) labeled CDOW Habitat Model into your machine.
3. Copy all of the files from the CD into the folder **Habitat_Assessment_Model** that you just created.
4. Remove the CD from your computer.
5. Navigate to the **Habiat_Assessment_Model** just created and locate the **habitat.avx** file. Copy this file to C:/ESRI/AV_GIS30/ARCVIEW/EXT32.
6. This completes the file transfer process.

Activating the Habitat Extension

1. Open Arcview 3.x and begin a new project.
2. Click **File** on the toolbar and select **Extensions**.
3. Activate the **Habitat Assessment Model** extension by clicking in the check box as shown in Figure 12.
4. Repeat this process to activate the **Spatial Analyst** extension.

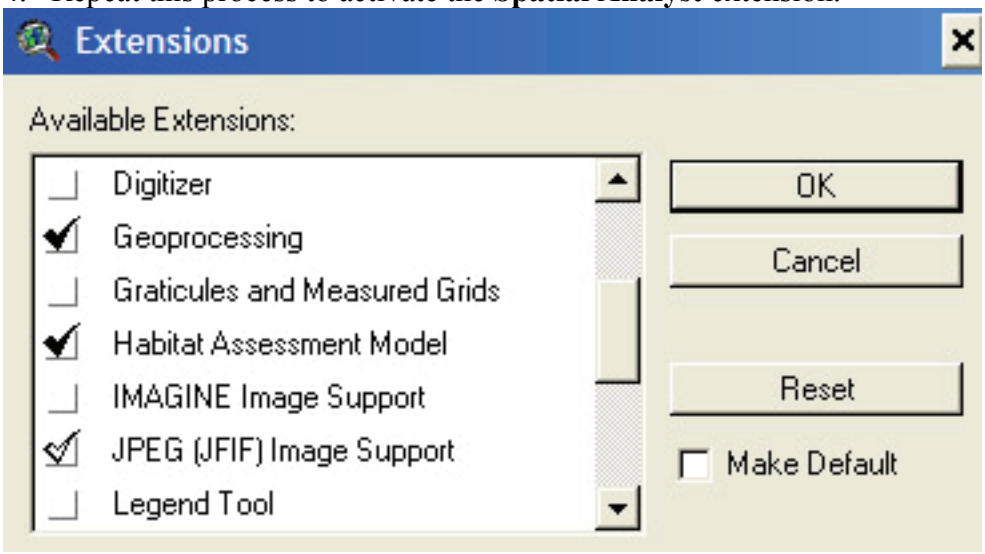


Figure 12. ArcView Extensions Window- The Habitat Assessment Model extension should now appear in the list of extensions in the Extensions window. Be sure the Spatial Analyst extension is also active while at this window.

5. Add a new view to the project.
6. Open the Add Theme Window.

7. Navigate to the directory containing all of the data copied from the CD. (This should be the **Habitat_Assessment_Model folder you created**).
8. Add all of the files that appear when "Feature Data Source" is selected as the "Data Sources Type" in the lower left corner of the **Add Theme** window.

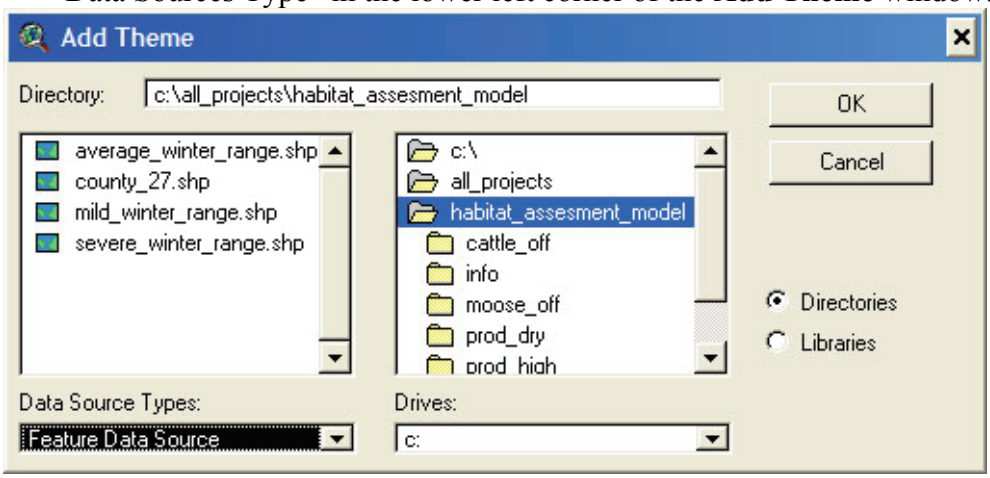


Figure 13. Arcview Add Theme Window- Be sure to add all the themes that appear as "Feature Data Source" and "Grid Data Source" while at the Add Theme Window.

9. Change the "Data Sources Type" to "Grid Data Source" and add all of these files to the view.
10. All necessary files should now be in the project to run the Habitat Assessment Model. Notice **Habitat Assessment Model** now appears on the Menu Bar at the top of the ArcView Window. It may be necessary to adjust the theme properties and theme orders to improve their display in the view window.

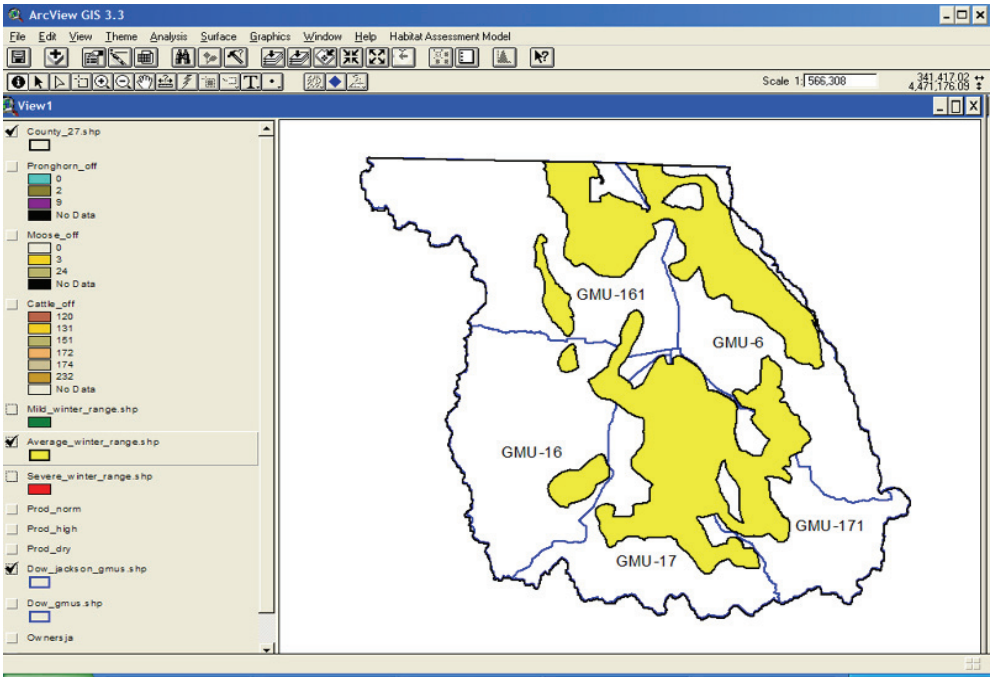


Figure 14. ArcView Toolbar with Habitat Assessment Menu Item

VII. Running the Habitat Model

After the Habitat Model has been properly installed and the Habitat Assessment Model menu item appears as a menu option, the model is ready to run.

1. To start running the Habitat Model, click the Habitat Assessment Model menu item and select "Run the Model".
2. The opening dialogue box, Figure 15, should appear displaying the model version information. Click the OK button.

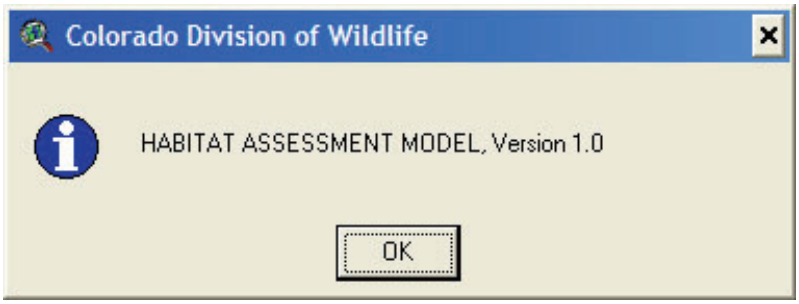


Figure 15. Habitat Assessment Model Opening Dialogue Box- This window signals the user that they have are about to run the Habitat Assessment Model. Notice this dialogue box also provides the model version information, which may be different than that shown above in your version.

3. Upon clicking OK, the Winter Utilization Areas Box will appear.

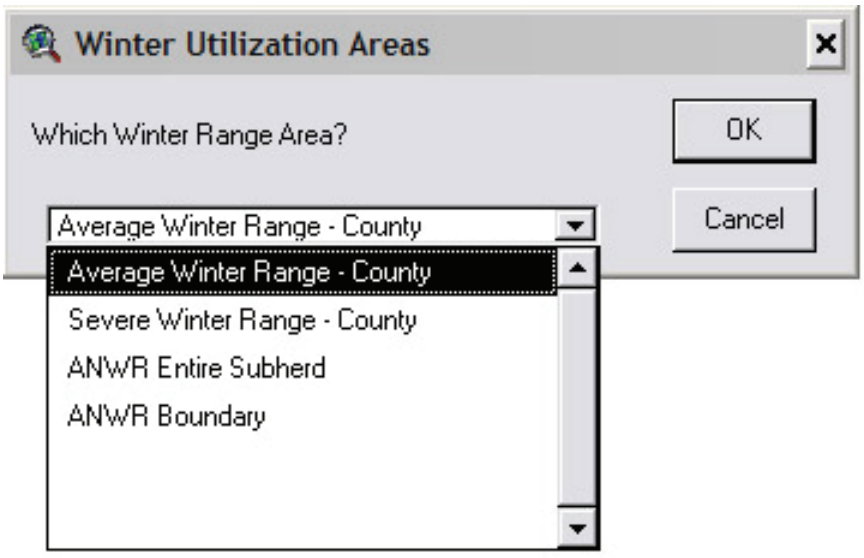


Figure 16. Winter Utilization Box- Select the appropriate winter range area.

4. The Winter Utilization Areas Box provides the user with a selection of four winter range areas for elk and mule deer populations. This selection determines which winter range area, outlined in Section III, will be used in the modeling scenario. Choose a winter utilization area from the list provided.
5. After selecting the Winter Utilization Area, the Prewinter precipitation pattern Box will open.

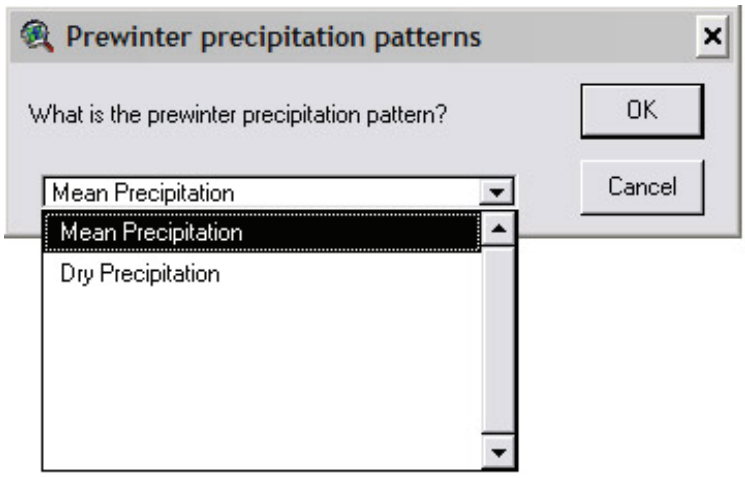
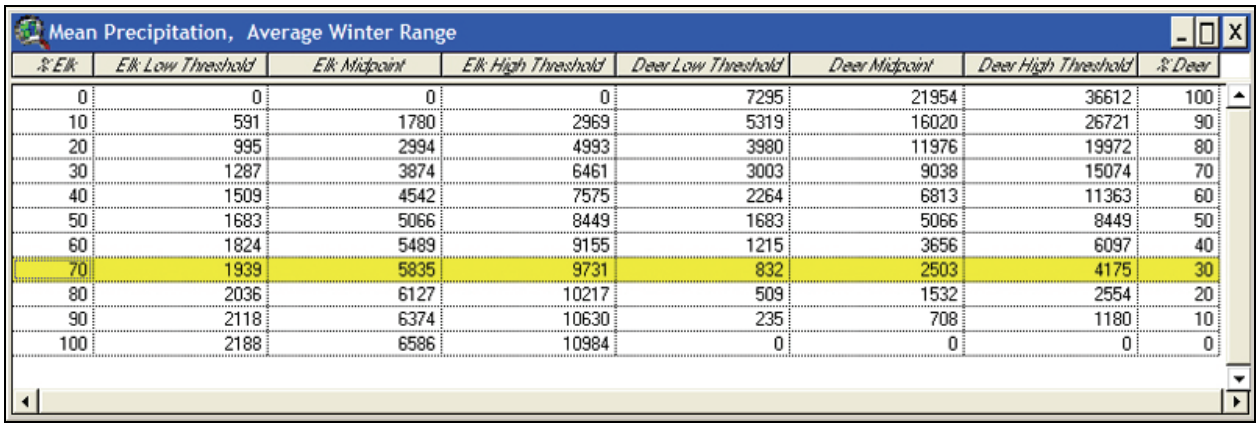


Figure 17. Prewinter Precipitation Box

The Prewinter Precipitation box provides the user with a choice of two precipitation patterns. This choice determines which production values, as described in Section III, will be used for determining elk and mule deer population estimates. A dry pattern corresponds to low production and a mean pattern corresponds to average production. Visit Section III of this manual for a review of the production value descriptions.

6. Depending on the location of the study, the Model will run the user through several additional menu items to determine all the input variables in the study area.
7. After the menu items, the Habitat Model will now produce an output table based on the selected criteria. Refer to Section VII for a description and interpretation of the output table results.

VIII. Interpreting the Habitat Model Results



Mean Precipitation, Average Winter Range

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	7295	21954	36612	100
10	591	1780	2969	5319	16020	26721	90
20	995	2994	4993	3980	11976	19972	80
30	1287	3874	6461	3003	9038	15074	70
40	1509	4542	7575	2264	6813	11363	60
50	1683	5066	8449	1683	5066	8449	50
60	1824	5489	9155	1215	3656	6097	40
70	1939	5835	9731	832	2503	4175	30
80	2036	6127	10217	509	1532	2554	20
90	2118	6374	10630	235	708	1180	10
100	2188	6586	10984	0	0	0	0

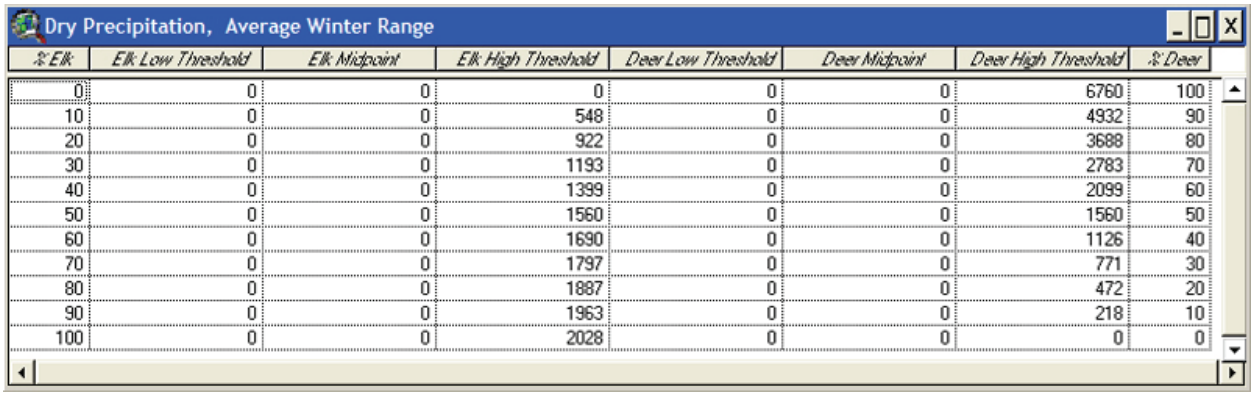
Figure 18. Habitat Model Results Table- This table contains predicted, sustainable population numbers for both elk and mule deer based on the input criteria selected.

Figure 18 provides an example of the table that is generated by the Habitat Model. This table contains predicted population numbers for both elk and mule deer based on the selected menu items in the model run. There are a number of key points to remember when interpreting the model output:

1. The conditions selected for the model run appear in the table title. For example, the table in Figure 18 was generated for mean precipitation and average winter range. In other study areas, multiple conditions exist and will appear in the title.
2. The first column (% Elk) and the last column (% Deer) of the table represent the percent of the total combined population of elk and mule deer composed by either elk or mule deer, respectively. The (% Elk) plus the (% Deer) must always equal 100 percent. Using the highlighted line in Figure 18 as an example, the combined population is composed of 70 percent elk and 30 percent mule deer.
3. The output table contains a low threshold, midpoint, and high threshold value for both elk and mule deer at all population structures. The low threshold value corresponds to consumption of 25 percent of ANPP, the midpoint equals 28.5 percent ANPP consumption, and the high threshold represents 32 percent ANPP consumption. Refer to Section V for a review of the implications associated with each threshold level. All results should be interpreted as threshold pairings. Using the highlighted example, the population at the low threshold would consist of 1,939 elk and 832 mule deer, the midpoint population would consist of 5,835 elk and 2,503 mule deer, while the high threshold totals would be 9,731 elk and 4,175 mule deer.
4. These population calculations are based on the premise that each individual within the population consumes 2 percent of their body weight in forage per day. The Habitat Model assumes each elk weighs 500 pounds and each mule deer weighs 150 pounds. Therefore, each elk is allocated 10 pounds of forage daily, and each mule deer receives 3 pounds of forage daily. Notice in Figure 18 that when the population is composed completely of elk (% Elk = 100) the low

threshold, midpoint, and high threshold values are 2,188, 6,586, and 10,984, respectively. However, when the population is 100 percent mule (% Deer = 100) there are 7,295, 21,954, and 36,612 individuals present, respectively. This difference in population values between elk and mule deer results from the difference in daily demand (10 pounds for elk, 3 pounds for mule deer), and it is important to understand the implications of this difference in the population calculations.

5. The population values presented in the output table are general guidelines. Many levels of complexity are involved in developing a model of this nature. Even though the output table provides an exact number, these values should be considered to have a margin of error +/- 20 percent.
6. Under certain model scenarios an output table may contain some zero value fields as shown in Figure 19.


Dry Precipitation, Average Winter Range

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	0	0	6760	100
10	0	0	548	0	0	4932	90
20	0	0	922	0	0	3688	80
30	0	0	1193	0	0	2783	70
40	0	0	1399	0	0	2099	60
50	0	0	1560	0	0	1560	50
60	0	0	1690	0	0	1126	40
70	0	0	1797	0	0	771	30
80	0	0	1887	0	0	472	20
90	0	0	1963	0	0	218	10
100	0	0	2028	0	0	0	0

Figure 19. Output Table Containing Zero Value Fields

These zero values under the precipitation and winter range conditions in this scenario indicate all the available forage at the low threshold and midpoint levels (removal of 25 percent and 28.5 percent AANPP, respectively) has been utilized by livestock and other wild ungulates**.** It does not mean that elk and mule are going to starve under these conditions. It means the ANPP utilization levels for the low threshold and midpoint have been exceeded by the livestock and other wild ungulate offtake. As a result, elk and mule deer will likely utilize less palatable forage and consume a greater portion of each individual plant in their foraging area. This can lead to an increased risk of habitat degradation.

IX. Conclusion

The Habitat Model was developed as a tool to ensure habitat sustainability while managing wild ungulate populations at the landscape level. As a cross boundary management tool, input from all responsible parties, including federal, state, and local agencies as well as local community members is critical to success. The HPP program provides a collaborative forum where the Habitat Model can be used and discussed in decisions relating to wild ungulate population management. The goal of the Habitat Model is to provide a range of population levels, and their associated risks and benefits. It is the task of the local stakeholders to set wild ungulate population numbers that meet their management objectives. However, forage availability is strongly impacted by climate. Since climatic conditions are variable, constant monitoring and evaluation is important to ensure wild ungulate population levels are in balance with habitat resources.

A primary goal of this project was to take complex ungulate-habitat interactions and include them in a GIS modeling tool that could be replicated for other areas of Colorado. In order to accomplish this goal, some assumptions and simplification of processes had to be made. As a result, the Habitat Model should only be used by individuals that have an understanding of these processes, and comprehend the complexity inherent in the model results. The results should not be taken out of the context of the Habitat Model and should only be presented when a full discussion of the Habitat Model can be included.

References:

Archer, F. and F.E. Smeins. 1991. Ecosystem-Level Processes, p.109-140. *In*: Heitschmidt, R.K. and J.W. Stuth (eds), Grazing Management: An ecological perspective. Timber Press, Inc. Portland, Oregon. USA.

Clements, F. E. 1916. Plant succession: An analysis of the development of vegetation. Carnegie Institute Publ. 242.

Cowardin, M. and M. Flenner. 2003. Colorado Division of Wildlife captures institutional knowledge using stand-up, real-time digitizing. Geoworld. 16:32-35.

Dysterhuis, E. J. 1949, Condition and management of range land based on quantitative ecology. Journal of Range Management. 2:104-115.

Heady H.F., and R. Dennis Child. 1994. Rangeland Ecology and Management. Westview Press. Boulder, CO.

Hobbs, N.T., D.L. Baker, G.D, Bear, and D.C. Brown. 1996. Ungulate Grazing in Sagebrush Grassland: Mechanisms of Resource Competition. Ecological Applications. 6:200-217.

Holechek, J.L and R.D. Pieper. 1992. Estimation of stocking rate on New Mexico rangelands. Journal of Soil and Water Conservation. 47:116-119.

Milchunas, D.G. and W.K. Lauenroth. 1993. Quantitative effects of grazing on vegetation and soils over a global range of environments. Ecological Monographs. 63:327-366.

Reed, F. Roath, L. and D. Bradford. 1999. The Grazing Response Index: A Simple and Effective Method to Evaluate Grazing Impacts. Rangelands. 21:3-6.

Wassink, J. L. 1993. Mammals of the Central Rockies. Mountain Press Publishing Company. Missoula, MT.

Weisberg, P.G., N. Thompson Hobbs, James E. Ellis and Michael B. Coughenour. 2002. An ecosystem approach to population management of ungulates. Journal of Environmental Management. 65:181-197.

Westoby, M. B., B. Walker, and I. Noy-Meir. 1989. Opportunistic management for rangelands not at equilibrium. Journal of Range Management. 42:266-274.

Yaffee, S.L., and J.M. Wondolleck. 1997. Building bridges across agency boundaries. *In* K.A. Kohm and J.F. Franklin (Eds.). Creating a forestry for the 21st century: The science of ecosystem management. Pages 381-396. Island Press. Washington, D.C.

Appendix 1. North Park, Colorado Habitat Assessment Model Case Study

A. Location

The North Park Study area encompasses all of Jackson County, CO. The geography of the area includes a central, dry parkland that is bordered on three sides by mountains. The area varies in elevation from 7,798 to 12,965 feet Annual precipitation averages 11 inches, with an annual temperature of 38 ^{o}F. Long, cold winters are punctuated by short, cool summers with a short growing season. Sagebrush grasslands on the basin floor transition to alpine communities with increases in elevation. The dominate vegetation cover by area is presented in Figure 20.

Vegetation Type	Percent Cover
Sagebrush Grassland	41
Forests	44
Irrigated Hayfields	8

Figure 20. Dominate North Park Vegetation- Percent land cover by dominate vegetation types.

The study area consists of five Division of Wildlife (DOW) Game Management Units (GMU's). They are GMU 6, GMU 16, GMU 17, GMU 161 and GMU 171 (Figure 21).

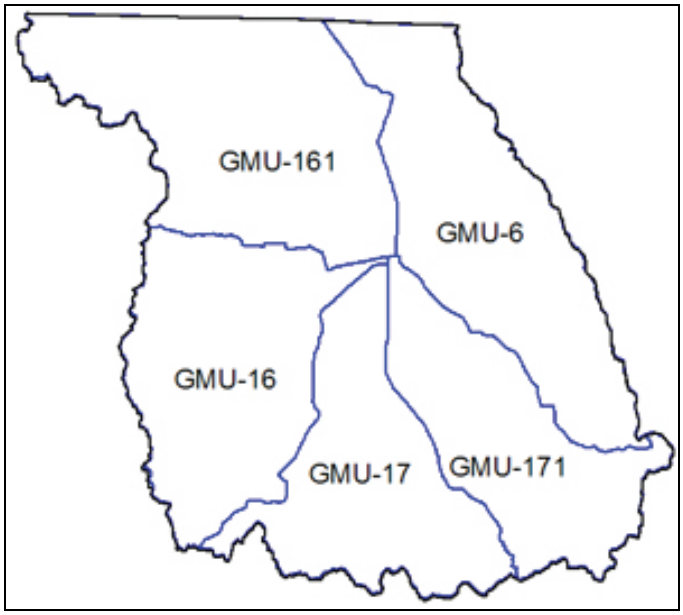


Figure 21. GMU's for the North Park Study Area

B. Project Partners

Participants involved in the project include the Habitat Model design team and the North Park Habitat Partnership Committee (HPP). The design team consists of the following personnel:

L. Roy Roath[1]- Project Lead
Gary Wockner[2]- Research Associate and Modeler
Erik Hardy[2]- Research Associate
Steve Porter[3]- HPP Coordinator and Technical Advisor
N.T. Hobbs[2]- Technical Advisor
Dave Freddy[3]- Technical Advisor

North Park HPP committee members include:

Landowner Representatives:

Danny Meyring
Blaine Evans
James Baller, Jr.

Sportsmen Representative:

Todd Peterson, Chairman

Bureau of Land Management Representative:

Dave Harr, Assistant Manager

Division of Wildlife Representative:

Kirk Snyder

US Fish & Wildlife Service Representative:

Mark Lanier

US Forest Service Representative:

Chuck Oliver, District Ranger

NRCS Representative:

Al White

Other assistance was provided by the following individuals:
Jay Widom – Colorado Division of Wildlife
Liza Graham- Colorado Division of Wildlife
Jerry Jack- Bureau of Land Management
Carol Brown

[1] Forest, Range, and Watershed Stewardship Department, Colorado State University
[2] Natural Resource Ecology Lab, Colorado State University
[3] Colorado Division of Wildlife, Fort Collins Field Office

C. Data Sources

The North Park project served as the pilot study for the Habitat Model. As the Habitat Model expands, each new area modeled will present a unique set of opportunities and challenges. The data sources listed below were the best available for the North Park study area, but each location will require a unique approach, and the methods used represent only one set of possible strategies. New methods will be necessary as the Habitat Model moves to new study areas.

1. Production Values

Prior to this project, there was no complete data set of vegetation production values for Jackson County, Colorado. As a result, production values for the North Park Study area are composed of a combination of USDA-NRCS SSURGO and STATSGO data (described in Section III of this manual) modified by field knowledge gained through previous field studies in the area. The Owl Mountain Partnership has conducted vegetation surveys in the Owl Mountain area of North Park in the years prior to the Habitat Model project. The information gained through these studies was used to modify the SSURGO and STATSGO range-site production values to better represent the current vegetation production potential for the area. Modifications were made by comparing range-site production values contained in the SSURGO and STATSGO data with information from vegetation surveys conducted by the Owl Mountain Partnership. Production value adjustments should only be made under the guidance of a range professional familiar with the study area.

2. Winter Range Polygons

Kirk Snyder and Jay Widom (North Park DWM's) met with the DOW GIS team in Walden, CO and modified the existing winter range polygons for elk, mule deer, moose and pronghorn (as described in Section III of this manual). The entire HPP committee then had the opportunity to view and change the winter range polygons using the SMART Board technology. This allowed committee members to see direct changes as a result of their feedback, creating a greater sense of data ownership for the HPP committee. This level of collaboration is necessary for a successful Habitat Model.

3. Other Wild Ungulate Offtake

Moose and pronghorn are also dominate wild ungulates in the North Park study area. Estimates of their winter population numbers were provided by the District Wildlife Manager (Kirk Snyder) for the North Park study area. From HPP committee discussion, it was determined that significant populations of pronghorn utilize the North Park study area at certain times of the year. Based on weather conditions and forage availability, some pronghorn leave the North Park study area and move to Wyoming or Middle Park.

No substantial estimates of this migratory population were available, as it is highly variable. As a result, the project team and North Park committee decided to allocate forage based on estimates of the resident population that utilizes winter range forage in North Park. This decision was based on the conclusion that winter forage availability is the primary control for wild ungulate populations in North Park, and trying to accurately capture migratory pronghorn populations would not significantly enhance the Habitat Model for this area.

4. Livestock Offtake

The landowner representatives on the North Park HPP committee played a key role in providing livestock numbers and distribution for the Habitat Model. The landowner representatives are long-time residents of North Park, and are all active members of the ranching community. They estimated an annual average livestock demand of approximately 411,000 AUM's for North Park. This estimate was verified by comparison to Colorado Agricultural Statistics for Jackson County. The livestock offtake grid was created in the following manner:

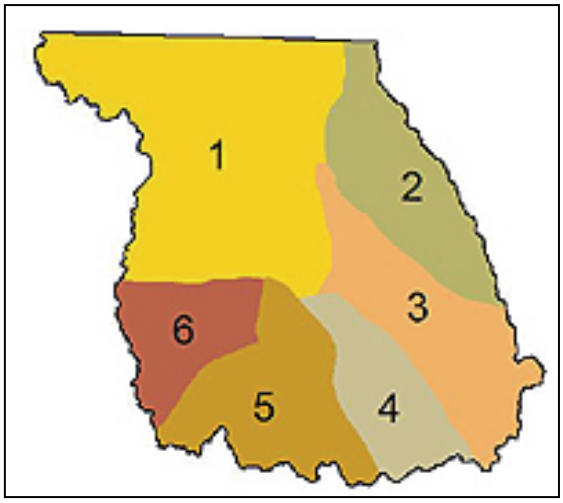


Figure 22. Cattle Offtake Regions of North Park Study Area.

1. Using their combined knowledge of livestock operations in North Park, the landowner representatives divided the study area into 6 regions (Figure 22). They estimated the number of AUMs for each livestock operation in each of the six regions. This step provided the total number of AUMs by region.

2. The livestock utilize North Park rangeland vegetation production for approximately six months of the year, with the additional demand being supplied through supplemental feeding. As a result, livestock demand on rangeland forage in each region was estimated as half the total number of

AUMs for that region. This produced a total demand of 205,500 AUMs for all of North Park.

3. The AUM demand for each region was then divided by the total land area of the region, creating a pounds per acre offtake value for the region (Figure 3).

4. This information was then converted into the livestock offtake grid for use in the Habitat Model.

Region	Area (Acres)	Offtake per Acre (lbs)
1	378,492	131
2	141,607	151
3	166,349	172
4	98,796	174
5	158,180	232
6	93,401	120

Figure 23. Livestock Offtake by Region for the North Park Study Area

D. Habitat Model Results

Entire County Results

Mean Precipitation, Average Winter Range - County

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	6851	21843	36835	100
10	555	1771	2987	4995	15939	26883	90
20	934	2979	5023	3736	11916	20092	80
30	1209	3855	6501	2821	8994	15167	70
40	1417	4519	7621	2126	6779	11432	60
50	1581	5041	8500	1581	5041	8500	50
60	1713	5462	9210	1141	3638	6134	40
70	1821	5806	9790	781	2491	4200	30
80	1912	6096	10280	478	1524	2570	20
90	1989	6342	10694	221	704	1187	10
100	2055	6553	11051	0	0	0	0

Figure 23. Model Output for the North Park Study Area- Output for the Habitat Model under Mean Precipitation and Average Winter Range. Highlighted results for the midpoint elk and mule deer populations are near estimates of current population numbers for the study area.

Based on estimates provide by the local DWM (Kirk Snyder), there are approximately 6,500 elk and 1,500 mule deer in the North Park study area. Under conditions of mean precipitation and an average winter range, these estimates coincide with the midpoint values of the Habitat Model results (6,096 elk, 1,524 mule deer) highlighted in Figure 24. In this scenario the population is composed of 80 percent elk and 20 percent mule deer. At the low threshold level, there would be 1,912 elk and 478 mule deer, while the high threshold level allows 10,280 elk and 2,570 mule deer. There is a large range in population values between the low and high threshold levels, but this range is based on a 7 percent increase in consumption of all ANPP in the winter range area.

The Habitat Model is built on the premise that there is a finite amount of a limiting resource (forage) to support the entire ungulate population and ensure habitat sustainability in the study area. Figure 25 provides a breakdown of ANPP allocation for mean precipitation and average winter range conditions. The average ANPP per acre across the entire study area is 717 lbs/acre.

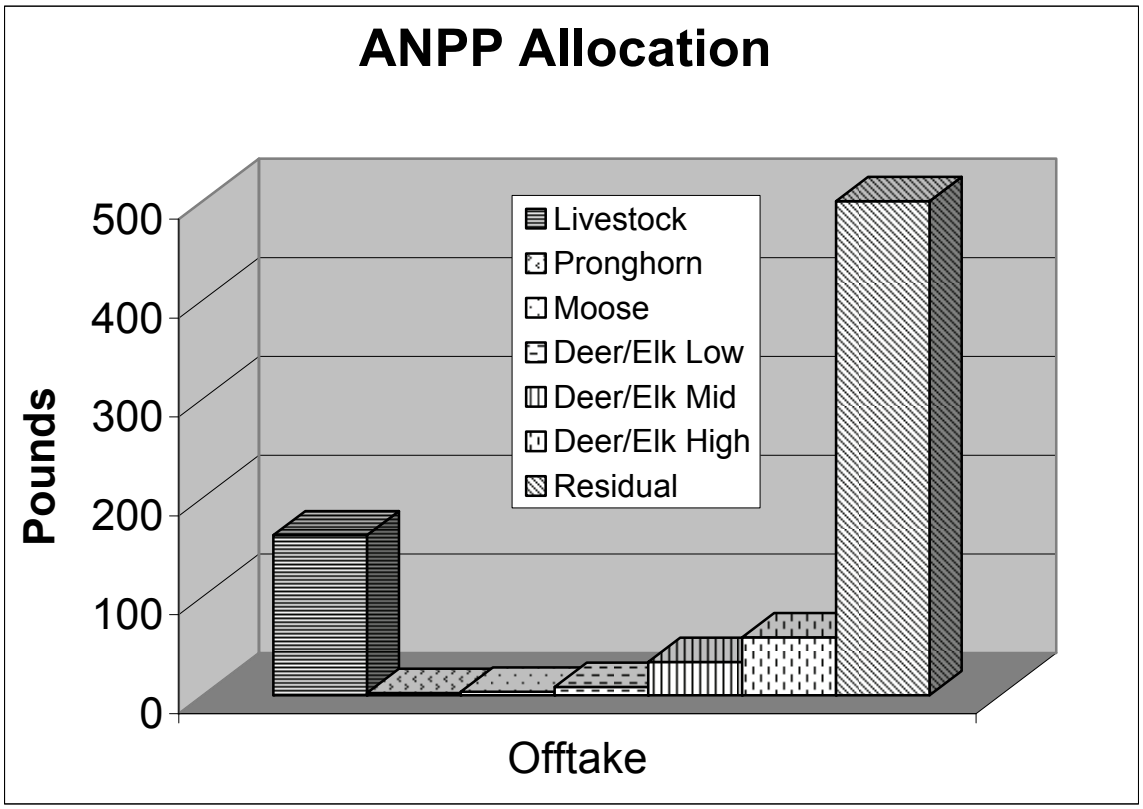


Figure 24. Forage Allocation Based on Mean Precipitation and Average Winter Range- The average ANPP per acre under these modeling conditions is 717 lbs. Deer/Elk low, mid, and high represent the low, midpoint, and high thresholds, respectively. Residual values indicate ANPP not consumed, and are between 488-538 lbs/acre depending on the threshold level used.

As shown in Figure 25, domestic livestock consume the majority of ANPP utilized by all ungulates. Mule deer and elk, even at the high threshold level, still consume significantly less than livestock, and use by moose and pronghorn is minimal. Since habitat sustainability is a key component within the Habit Model, 488 to 538 pounds of ANPP are left as residual biomass to maintain ecosystem health.

Annual variation in climate is still the major variable in controlling the amount of ANPP available from year to year in the North Park study area. A single target population is not appropriate for all conditions, as a result, it is critical to actively manage and adjust wild ungulate populations to compliment changes in forage availability.

Refuge Subunit Results

The North Park HPP committee was also interested in addressing a subunit within the boundaries of the overall study unit. This subunit consists of the Arapaho National Wildlife Refuge (ANWR) and the surrounding lands. The committee felt that the elk and mule deer utilizing this area could be treated as a distinct herd, and therefore a modeling effort in this area would yield valid results. The Habitat Model can be run on the entire subunit or only the lands within the ANWR boundary. Figure 26 shows these areas.

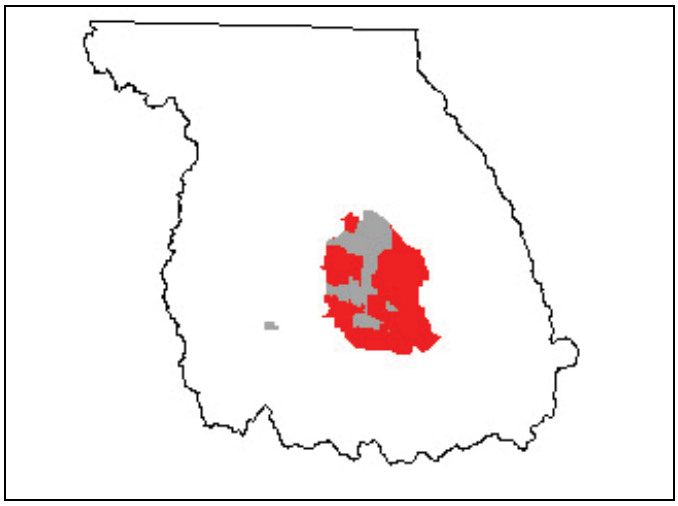


Figure 25. Habitat Model Subunit Area- The area in red shows the entire subunit area and represents the entire range used by the wintering subherd. The area in gray denotes the ANWR boundary.

Livestock Offtake

The offtake value of 298 lbs/acre for the area within the ANWR boundary was generated from information provided by ANWR personnel. The value for the area outside of the ANWR boundary of 169 lbs/acre was based on a combination of information from local landowners and grazing allotment numbers provided by the BLM.

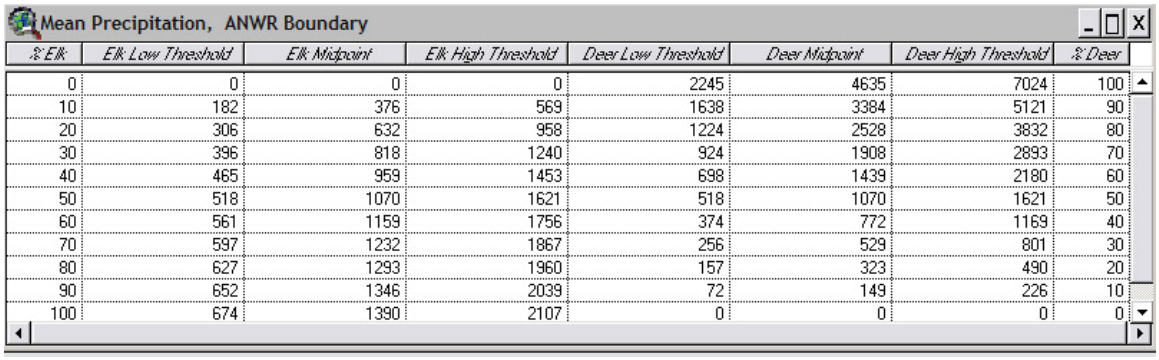
Results Table

Mean Precipitation, ANWR Entire Subherd

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	4279	9553	14827	100
10	347	775	1202	3123	6975	10818	90
20	583	1303	2022	2332	5212	8088	80
30	755	1686	2617	1761	3933	6105	70
40	885	1977	3068	1328	2966	4602	60
50	987	2205	3422	987	2205	3422	50
60	1070	2389	3707	713	1591	2469	40
70	1137	2539	3941	488	1089	1691	30
80	1194	2666	4138	299	667	1035	20
90	1242	2774	4305	138	308	478	10
100	1284	2866	4448	0	0	0	0

Figure 26. Entire Subherd Sample Results

Based on an average precipitation year, and using the midpoint threshold value, the entire subherd area could support approximately 2666 elk and 667 mule deer (based on a herd ratio of 80 percent elk and 20 percent mule deer).



Mean Precipitation, ANWR Boundary

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	2245	4635	7024	100
10	182	376	569	1638	3384	5121	90
20	306	632	958	1224	2528	3832	80
30	396	818	1240	924	1908	2893	70
40	465	959	1453	698	1439	2180	60
50	518	1070	1621	518	1070	1621	50
60	561	1159	1756	374	772	1169	40
70	597	1232	1867	256	529	801	30
80	627	1293	1960	157	323	490	20
90	652	1346	2039	72	149	226	10
100	674	1390	2107	0	0	0	0

Figure 27. ANWR Boundary Sample Results

Based on an average precipitation year, and using the midpoint threshold value, the ANWR boundary area could support approximately 1293 elk and 323 mule deer (based on a herd ratio of 80 percent elk and 20 percent mule deer).

Just as with the model results for the entire county, annual variation in climate remains the major variable in controlling the amount of ANPP available from year to year in the North Park study area. A single target population is not appropriate for all conditions, as a result, it is critical to actively manage and adjust wild ungulate populations to compliment changes in forage availability.

All of the values produced using this model are estimates and should only be used for discussion by individuals who understand all of the factors affecting these estimates.

Appendix 2. Middle Park, Colorado Habitat Assessment Model Case Study

A. Location

The Middle Park study area consists of Grand County, the Blue River portion of Summit County, the Sheephorn Valley and areas northwest of Piney Ridge to the Colorado River and east of Highway 131 in Game Management Unit (GMU) 36 in Eagle County. In addition to privately owned land, the study area contains lands administered by the Bureau of Land Management, United States Forest Service, National Park Service, Colorado Division of Wildlife, and other state and local agencies. The area varies in elevation from 6,750 to more than 13,000 feet above sea level.

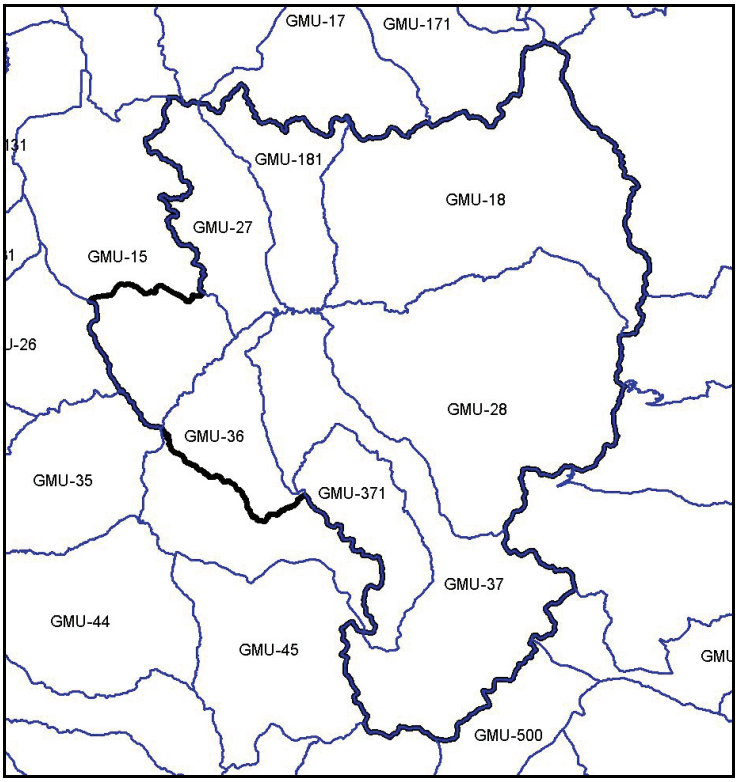


Figure 27. GMUs for the Middle Park Study Area

B. Project Partners

1. Participants involved in the project include the Habitat Model design team and the Middle Park Habitat Partnership Committee (HPP). The design team consists of the following personnel: Gary Wockner- Research Associate and Modeler, Erik Hardy- Research Associate, Tim Davis- HPP Coordinator and Technical Advisor, N.T. Hobbs- Principal Investigator, Dave Freddy- Technical Advisor.

Middle Park HPP committee members include:

Landowner Representatives:	Division of Wildlife Representative:
Duane Scholl	Bob Thompson
Dave Hammer	
Chuck Alexander	National Park Service Representative
Sportsmen Representative:	Larry Gamble
Barry Smith	US Forest Service Representative:
Mike Garrett	
	Doreen Sumerlin
Bureau of Land Management Representative:	NRCS Representative:
Chuck Cesar	Mark Volt
Technical Assistance	
Susan Cassel – Administrative Assistance	
Andy Holland – Division of Wildlife	

C. Data Sources

The Middle Park project was the second field application of the Habitat Model. Similar to the North Park study area, the Middle Park area presented a new and unique set of opportunities and challenges. The data sources listed below were the best available for the Middle Park study area, but each location will require a unique approach, and the methods used represent only one set of possible strategies. New methods will be necessary as the Habitat Model moves to new study areas.

1. Production Values

Production values for the Middle Park study area are composed of USDA-NRCS STATSGO data (described in Section III of this manual) modified by field knowledge provided by local agency personnel. Production value adjustments should only be made under the guidance of a range professional familiar with the study area. Unlike the North Park study area, no SSURGO data was available for the Middle Park Study area at the time this model was generated. Revised production data could be available as soon as January 2005. This updated SSURGO information could be used in the future to further refine this model.

2. Winter Range Polygons

The winter range polygons for the Middle Park study area had just been revised as part of the CDOW WRIS mapping project. Upon discussion with the HPP committee members it was decided that the WRIS winter range polygons were accurate for the area and no further modification was necessary.

3. Other Wild Ungulate Offtake

Moose and pronghorn are also dominant wild ungulates in the Middle Park study area. Estimates of their winter population numbers were provided by the District Wildlife Manager (Bob Thompson).

4. Livestock Offtake

The landowner representatives on the Middle Park HPP committee provided livestock numbers and distribution for the Habitat Model. The landowner representatives are long-time residents of Middle Park, and are all active members of the ranching community. Since Middle Park livestock numbers have been in decline due to encroaching development and unusual drought, the committee requested that the Habitat Model contain two different stocking levels. The first livestock stocking level is based on a 20-year historic average as provided by the landowners on the committee. To represent a decreased stocking rate, as seen in the Middle Park area over the last 5 years, the 20-year stocking level was decreased by 30 percent. As the model user clicks through the menu options, both a 20-average and a 5-year average are offered as modeling scenarios. Further revisions relating to stocking rates may be necessary in the future, depending upon committee needs.

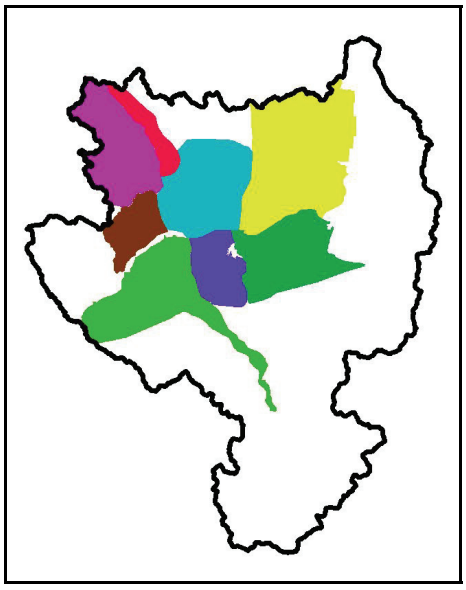


Figure 28. Livestock Offtake Regions of the Middle Park Study Area

The Middle Park HPP landowners provided information that could be distilled into 8 regions for the study area. Livestock offtake values for these regions for the 20-year

historic average varied from a low region of 89 pounds per acre to a high region of 630 pounds per acre. These values represent the varying levels of livestock utilization across the landscape and account for differences in available forage for elk and deer utilization across DAU administrative boundaries. The steps below outline the process for calculating livestock offtake in the Middle Park Study Area.

1. Using their combined knowledge of livestock operations in Middle Park, the landowner representatives divided the study area into 8 regions (Figure 28). They estimated the number of AUM's for each livestock operation in each of the 8 regions. This step provided the total number of AUM's by region.

2. The AUM demand for each region was then divided by the total land area of the region, creating a pounds per acre offtake value.

3. This information was then converted into a livestock offtake grid for use in the Habitat Model.

C. Habitat Model Results

Entire Study Area Results

Mean Precipitation, Winter Range - Whole Park

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	37598	64451	91304	100
10	3049	5226	7403	27441	47034	66627	90
20	5127	8789	12451	20508	35156	49804	80
30	6635	11374	16113	15479	26536	37592	70
40	7779	13335	18890	11669	20003	28335	60
50	8677	14873	21070	8677	14873	21070	50
60	9401	16115	22830	6261	10733	15205	40
70	9993	17131	24268	4287	7349	10411	30
80	10493	17986	25480	2623	4497	6370	20
90	10916	18712	26508	1212	2077	2942	10
100	11280	19335	27391	0	0	0	0

Figure 29. Model Output for the Middle Park Study Area- Output for the Habitat Model under Mean Precipitation, Average Winter Range, and 20-year average livestock offtake. Highlighted results for the midpoint elk and mule deer populations are within 10 percent of 2003 post hunt population size estimates.

Current population estimates of combined elk and mule deer herds in Middle Park suggest that approximately 30% of the total number of animals are elk and 70% are mule deer. Given this ratio, the Habitat Model predicts the entire Middle Park HPP Study area can support a population of 26,536 mule deer and 11,374 elk given mean precipitation, average winter range, and 20-year average livestock offtake.

The Habitat Model is built on the premise that there is a finite amount of limiting resource (forage) to support the entire ungulate population and ensure habitat sustainability in the study area. Figure 30 provides a breakdown of ANPP allocation for

mean precipitation, average winter range conditions, and 20-year average livestock offtake.

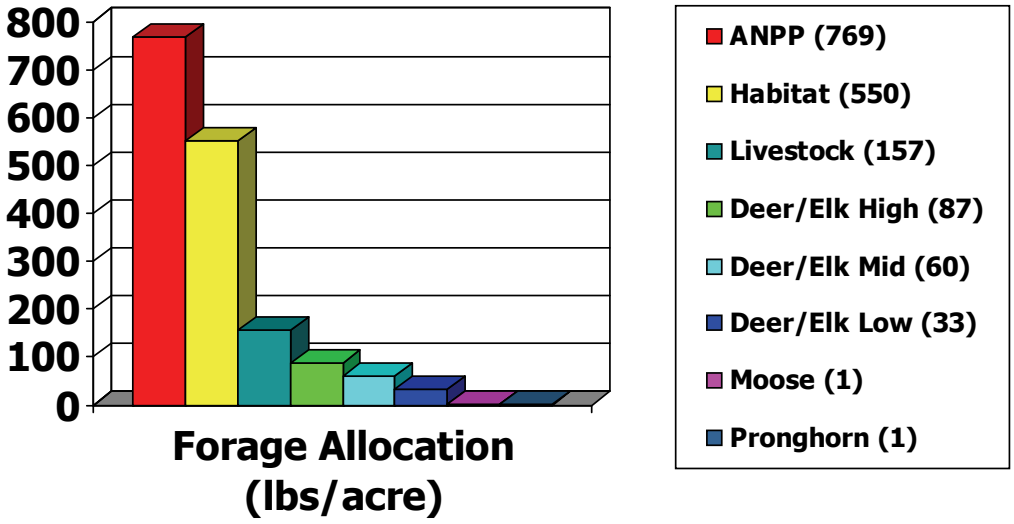


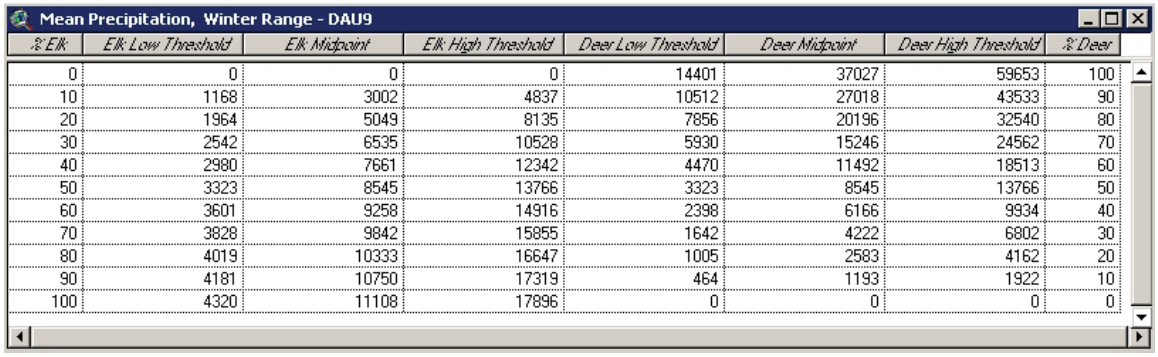
Figure 30. Forage Allocation Based on Mean Precipitation, Average Winter Range, and 20-year Average Livestock Offtake. The average ANPP per acre under these conditions is 769 lbs. Deer/Elk low, mid, and high represent the forage consumed for the low, midpoint, and high thresholds, respectively. 550 lbs of forage are left unconsumed for habitat sustainability.

The model also has available menu options to run on the following deer and elk DAUs: E7, E8, E12, E13, D8, D9. Each of the model results in these units can be compared to actual and objective numbers for each unit. Figures 31 and 32 below offer model results for Elk DAU 13 and Deer DAU 9, respectively, with average precipitation, winter range, and 20-year livestock offtake.

Mean Precipitation, Winter Range - EAU13

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	25596	35316	45036	100
10	2075	2863	3652	18675	25767	32868	90
20	3490	4816	6141	13960	19264	24564	80
30	4517	6233	7948	10538	14542	18543	70
40	5296	7307	9318	7944	10961	13977	60
50	5907	8150	10393	5907	8150	10393	50
60	6400	8830	11261	4262	5881	7500	40
70	6803	9387	11970	2918	4027	5135	30
80	7143	9856	12568	1786	2464	3142	20
90	7431	10253	13075	825	1138	1451	10
100	7679	10595	13511	0	0	0	0

Figure 31. Model Results for Elk DAU 13



Mean Precipitation, Winter Range - DAU9

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	14401	37027	59653	100
10	1168	3002	4837	10512	27018	43533	90
20	1964	5049	8135	7856	20196	32540	80
30	2542	6535	10528	5930	15246	24562	70
40	2980	7661	12342	4470	11492	18513	60
50	3323	8545	13766	3323	8545	13766	50
60	3601	9258	14916	2398	6166	9934	40
70	3828	9842	15855	1642	4222	6802	30
80	4019	10333	16647	1005	2583	4162	20
90	4181	10750	17319	464	1193	1922	10
100	4320	11108	17896	0	0	0	0

Figure 32. Model Results for Deer DAU 9

The model options include seven different geographic boundaries (all DAUs and the whole park), three different precipitation patterns (wet, mean, and dry), and two different livestock offtake levels. Given these 7x3x2 options, the model can produce 42 different output tables to be scrutinized depending on interpretative needs.

The values produced using this model are estimates and should only be used for discussion by individuals who understand all of the factors affecting these estimates.

Appendix 3. Northwest Colorado Habitat Assessment Model Case Study

A. Location

The Northwest Colorado study area comprises almost six million acres in the northwest part of the state. Because wild ungulates (elk, deer, and pronghorn) migrate through the entire area—rather than restricting themselves to DAU or HPP boundaries—the model was created to run on the whole area and multiple sub-areas within the greater boundary. The northwest study area includes three HPP committee boundaries, Upper Yampa River, Northwest Colorado, and Lower Yampa/White River. It includes DAUs 1, 2, 6, and 7, and nineteen GMUs.

Including all of Moffat County and parts of Rout, Garfield, and Rio Blanca counties, the northwest study area begins in the mountainous areas of the Park Range and the Flat Tops to the east, and covers all the area to the west to the state line. In addition to privately owned land, the study area contains lands administered by the BLM, USFS, NPS, CDOW, and other state and local agencies.

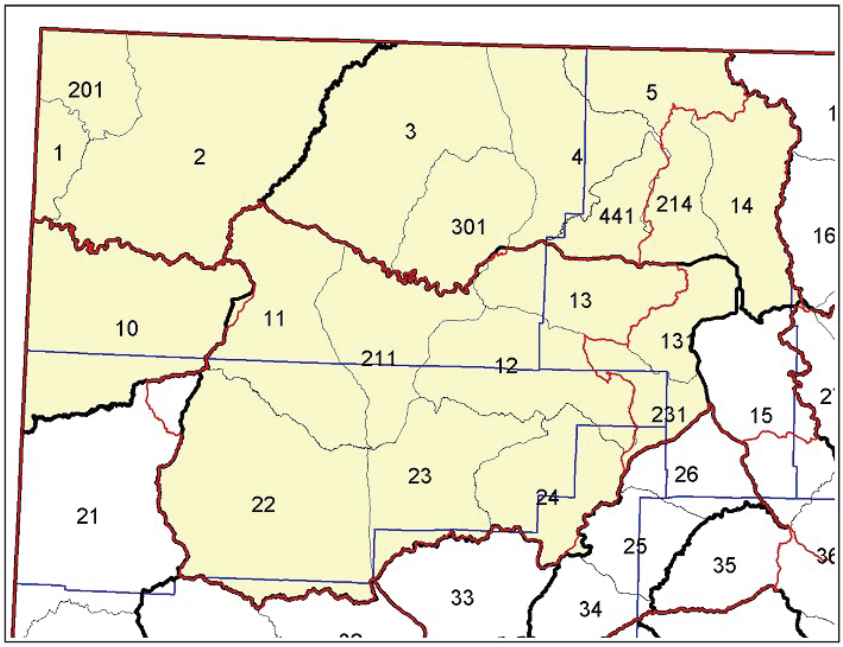


Figure 33. GMUS (thin black) for the Northwest Study Area (shaded). HPP boundaries are in red. DAU boundaries are thick black. County boundaries are blue.

B. Project Partners

Participants involved in the project include the Habitat Model design team and the Northwest Colorado and Lower Yampa/White River Habitat Partnership Committees.

The design team consists of the following personnel: Gary Wockner- Research Associate and Modeler, Randy Boone - Research Scientist, Tim Davis- HPP Coordinator and Technical Advisor, N.T. Hobbs- Principal Investigator. In addition to the design team, all members of both HPP committees were actively involved in creating the model, a process which took place over several meetings and presentations at Craig and Meeker locations. Brad Petch, CDOW Wildlife Conservation Biologist, served as the primary contact with the design team. Brad set up all the meetings, provided the design team with most of the data, and is the CDOW staffer who will be running and implementing the model for the three HPP committees.

C. Data Sources

The Northwest Colorado project was the third field application for the Habitat Model. The area presented several new challenges for the design team. The size of the area was a new challenge, as the other previous areas were smaller and more homogeneous. Also, because wild ungulates migrated throughout the entire system, modeling multiple DAUs/GMUs/HPP boundaries was a new challenge. The data sources below represent the best fit for the needs of the model.

1. Production Values

Production values for the Northwest study area are composed of a combination of USDA-NRCS SSURGO and STATSGO data (described in Section III of this manual) and are modified by local knowledge. SSURGO data exists for most of the study area except in land owned by the USFS in the eastern portion of the area. SSURGO data exists for most of the winter range which is the primary interest of the model application. The image below depicts the production map for the area where the finer-resolution polygons on the west are from SSURGO data and the course-resolution polygons on the east are from STATSGO data.

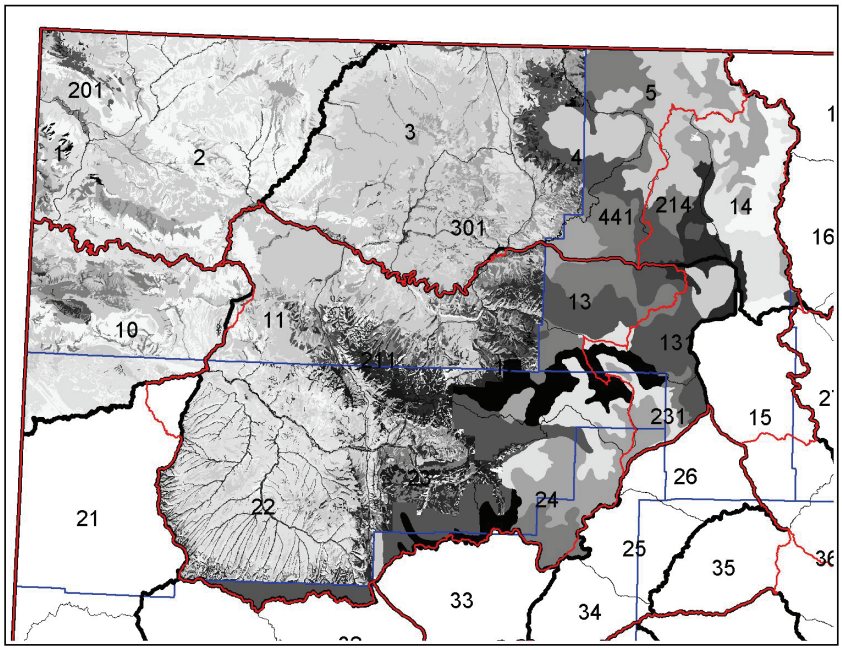


Figure 34. Production map for Northwest Colorado.

2. Winter Range Polygons

The winter range polygons for the three Northwest HPP committee areas had just been revised as part of the CDOW WRIS mapping project. Upon discussion with the HPP committee members, it was decided that the WRIS winter range polygons were accurate for the area and no further modification was necessary. Unlike the previously modeled study areas, the northwest area contains a significant amount of winter range. Of the approximately 6 million acres of in the study are, about 4.5 million are elk and deer winter range. The map below depicts the winter range areas:

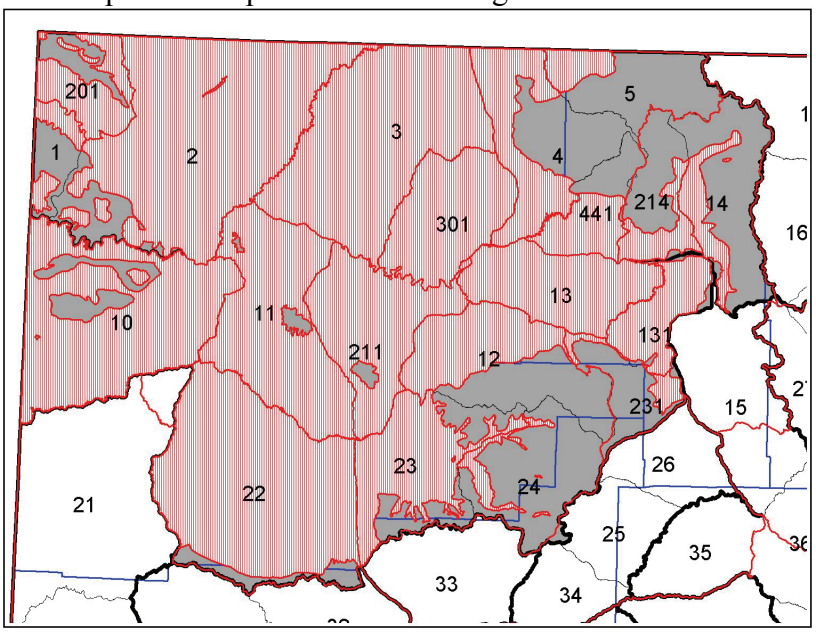


Figure 35. Red areas are elk and deer winter range.

3. Other Wild Ungulate Offtake

Pronghorn are also dominant wild ungulates in the Northwest study area, with current numbers around 18,000 animals. Because the committees wished to use pronghorn as a variable in the model, pronghorn are not dealt with in the same manner as they were in the North Park and Middle Park models. Here, pronghorn numbers can be varied along with elk and deer numbers. Results tables will express a range for all three species as will be defined in Part D, "Model Operation." Below, the pronghorn range is depicted.

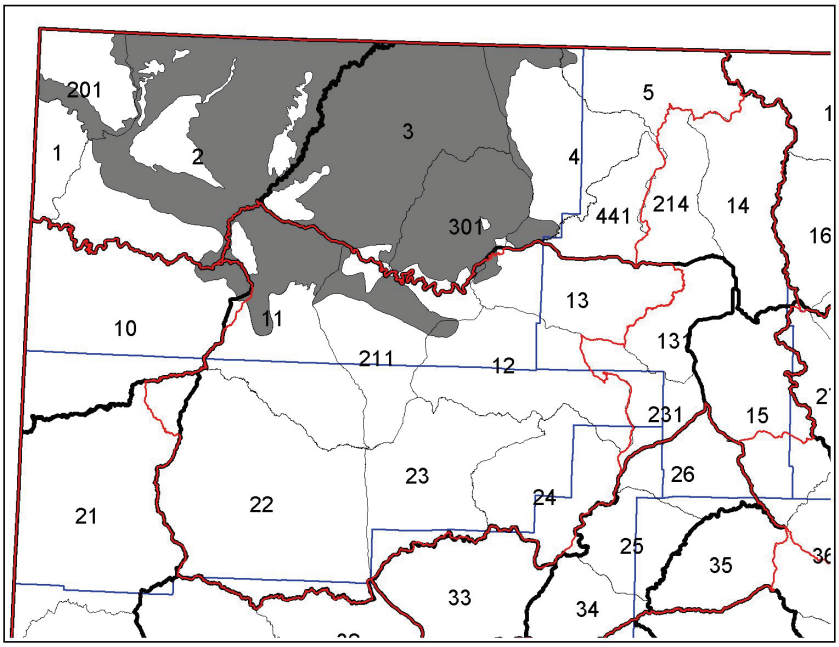


Figure 36. Pronghorn distribution in Northwest Colorado.

4. Livestock Offtake

Unlike the North Park and Middle Park study areas, which both had less than twenty livestock producers in the whole area, the Northwest area has more than a hundred. With this many producers it is unfeasible to use the procedure used in the North and Middle Park, which was to contact each producer and obtain both the number of livestock and the areas they graze.

Instead, domestic livestock numbers (cattle and sheep) were obtained from State of Colorado Agricultural Statistics documents wherein livestock numbers are reported by county for all of Colorado. Given this county-level data, livestock offtake was refined by using satellite imagery which measures the vegetation's greenness across the landscape. These satellite images have been used throughout the world to predict livestock stocking rates by correlating the greenness visible on the landscape with the productivity of the vegetation, and therefore with the number of animals that can be supported. The map below spreads the county-level livestock offtake across the landscape as predicted by the greenness seen from satellite images through the year. The shades/numbers represent 12 months of livestock grazing per year on the landscape.

As per the requests of committee members, in the model, livestock offtake can be varied in two ways: 1) by the length of time livestock are on the selected range, and 2) by the number of animals grazing. The details of these variations are discussed in the Part D.

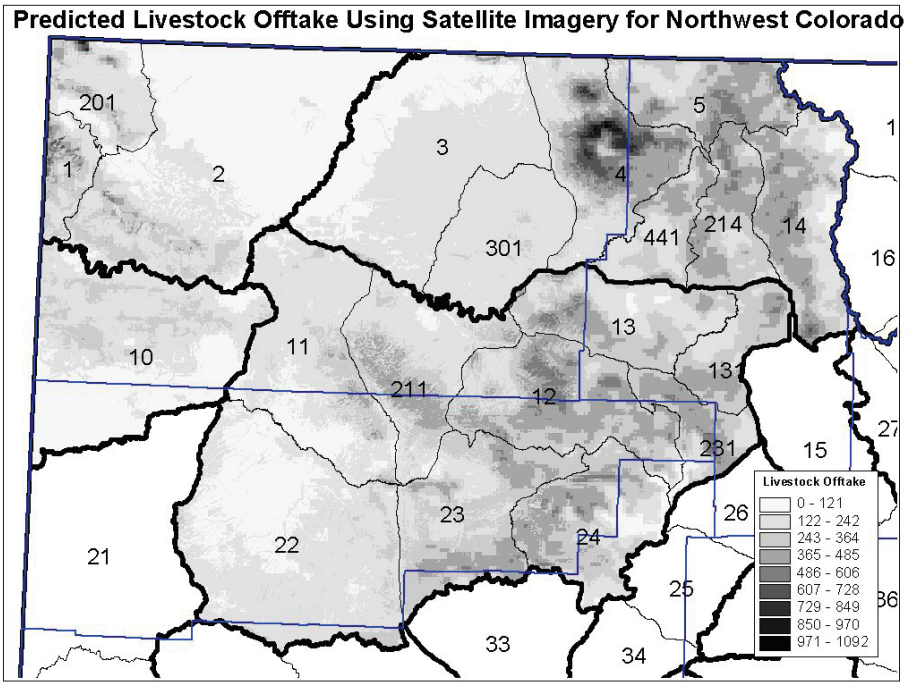


Figure 37. Livestock offtake predicted from satellite images and state statistics.

D. Model Operation

Because the Northwest model operation is a bit more complicated than the stock version which was used in North and Middle Parkd, this section runs the operator through the details of operating the model. The committee members, and CDOW staffer Brad Petch, requested a number of enhancements in the model to allow them to ask and answer finer-scale questions which can hopefully tease out better management practices in the Northwest areas.

After the model is installed, the Habitat Assessment Model menu item appears at the top menu bar in ArcView.

1. To start the model, click the Habitat Assessment Model menu item, and select "Run the Model."

2. The opening dialogue box, below, will appear. Click the "OK" button.

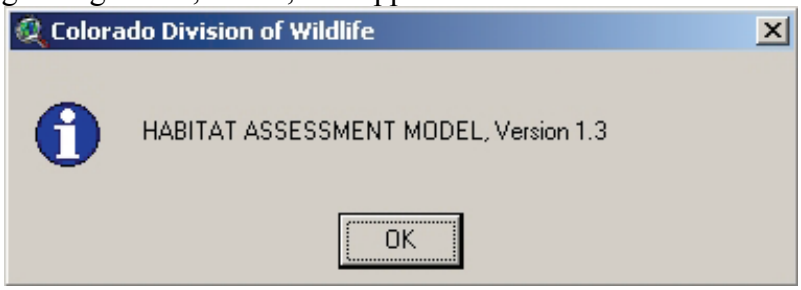


Figure 38. Opening Dialogue Box.

3. The next menu item that appears (below), the "Winter Utilization Areas" allows the user to select one of 25 winter utilization areas to be modeled. These areas include the whole study area, all four DAUs, and all 19 GMUs. This selection determines which winter range area, outlined in Section III, will be used in the modeling scenario.

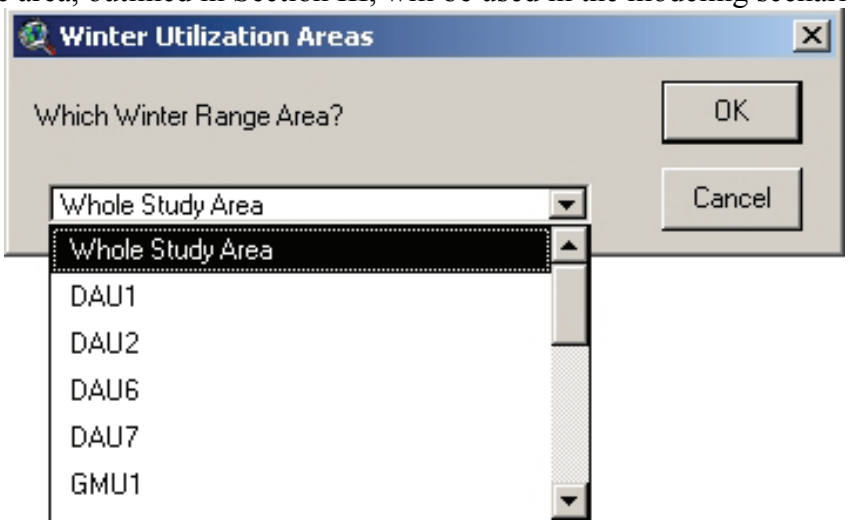


Figure 39. Winter Utilization Areas Dialogue Box.

4. The next menu choice, below, the "Prewinter Precipitation Patterns," provides the user with three precipitation patterns. This choice determines which production values, as described in Section III, will be used for wild ungulate population estimates. Mean, dry, and wet precipitation patterns correspond with average, below average, and above average forage production.

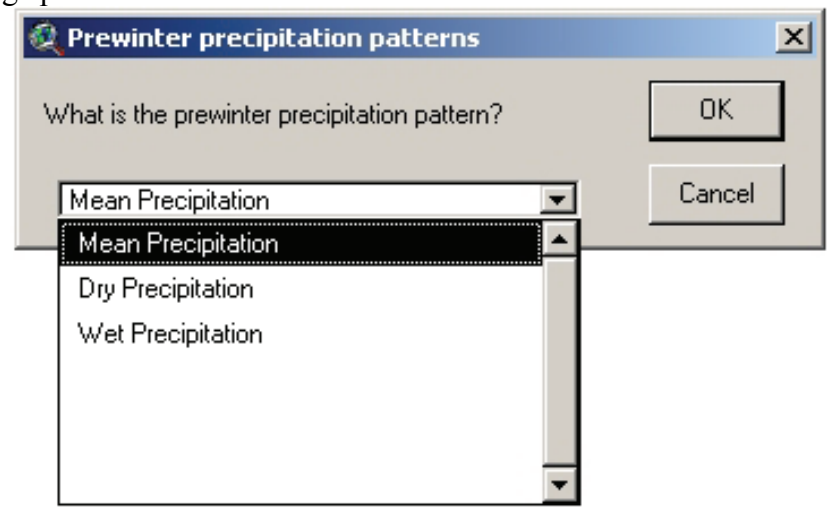


Figure 40. Prewinter Precipitation Dialogue Box.

4. Next, the user gets to choose the number of pronghorn to be modeled in the chosen area. Pronghorn number options range from 1,000 to 20,000. The results table will be generated based on this pronghorn choice.

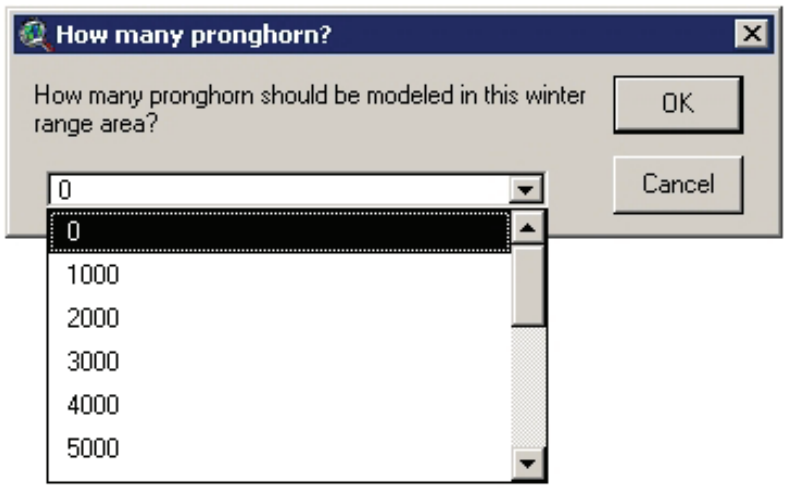


Figure 41. Pronghorn Dialogue Box.

5. The next choice (Figure 42) is the "Livestock Grazing Intensity." Two choices are available, the "Livestock High in 1997," and "Livestock Ten-Year Average." Over the past four years, significant destocking has occurred in Northwest Colorado as a result of drought, and because some landowners are switching operations over to outfitting businesses or choosing not to stock the land. Thus, the "Ten-Year Average" represents a smaller number of livestock on the landscape (about 84% of the high in 1997). The high in 1997, on the other hand, might represent a historically high number of livestock that could be run on the landscape. The HPP committees requested this option in the model.

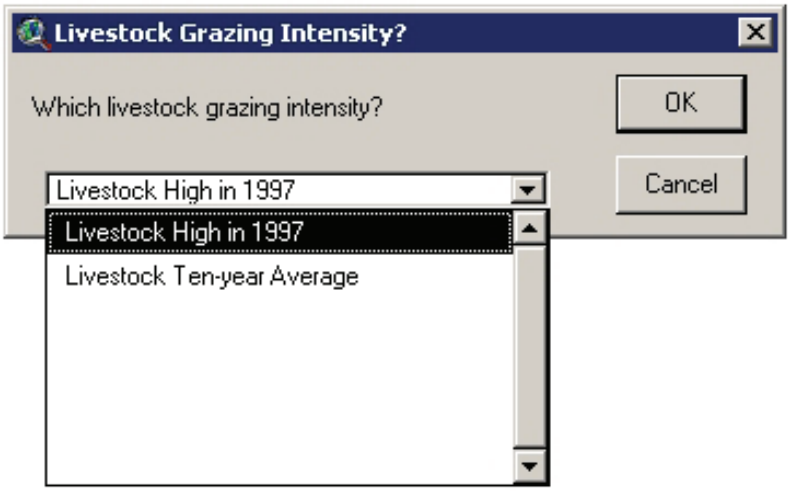


Figure 42. Livestock Grazing Intensity Dialogue Box.

6. The “Livestock Utilization Period,”—the next menu item, below—allows the user to determine how many months per year livestock are utilizing the chosen study area. For the whole study area, it appears that “12 months” is the most likely scenario. But, on smaller GMUs here and there, differences may occur. The HPP committees requested this option in the model.

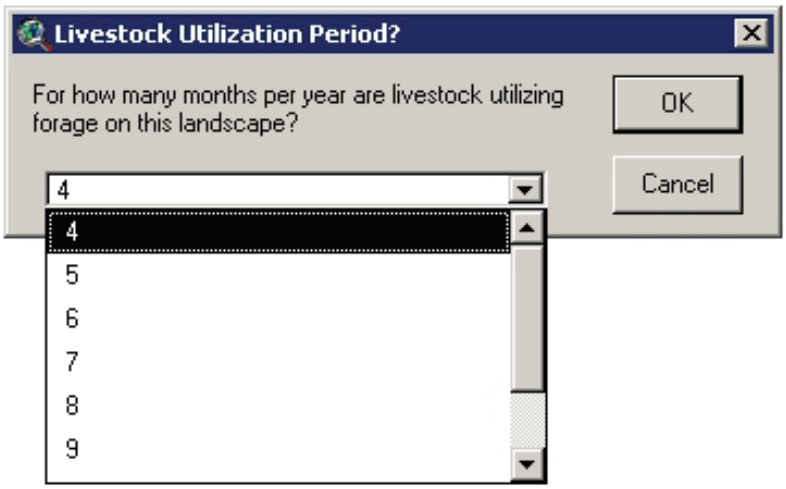


Figure 43. Livestock Utilization Period Dialogue Box.

7. The “Wildlife Utilization Period,”—the next menu item, below—allows the user to determine how many months per year elk, deer, and antelope are using the chosen study area. For the whole study area, it appears that “6 months” is the most likely scenario. But, on smaller GMUs here and there, differences may occur. The HPP committees requested this option in the model.

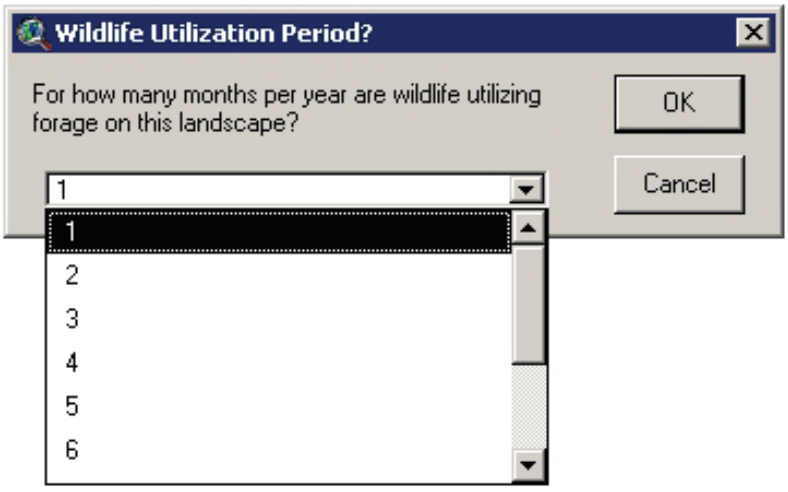


Figure 44. Wildlife Utilization Period Dialogue Box.

E. Habitat Model Results for Northwest Colorado

Because the Habitat Model in the Northwest area has been developed to run for multiple committees, numerous study areas, and with several variables, several hundred different results tables can be generated. In the discussion below we present a few of the potential results tables with some associated interpretation.

The biggest question the committees face is about the overall herd in the combined DAUSs 1, 2, 6, and 7. In figures 45 and 47 two results options are given which offer different ways to answer this question.

Mean Precipitation, Whole Study Area, 16000 Pronghorn, Livestock High in 1997, 12 months livestock, 6 months wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	0	164394	373239	100
10	0	13329	30263	0	119961	272367	90
20	0	22417	50896	0	89668	203584	80
30	0	29012	65870	0	67685	153675	70
40	0	34012	77222	0	51018	115833	60
50	0	37937	86132	0	37937	86132	50
60	0	41105	93325	0	27376	62154	40
70	0	43695	99204	0	18745	42559	30
80	0	45877	104160	0	11469	26040	20
90	0	47729	108363	0	5298	12028	10
100	0	49318	111972	0	0	0	0

Figure 45. Sample Results for the Whole Study Area specified by the table title.

Figure 45, above, offers results that are specified in the title of the table. Each of the variables in the title can be manipulated by the model, but overall, the committees have agreed that the above results may represent the most likely scenario that approximates current conditions in the whole Northwest study area. One caveat in this is that Figure 45 is generated for "Livestock High in 1997," whereas actually livestock numbers may be lower. To address this caveat, the results table in figure 47 was generated for the "Livestock Ten-Year Average." The highlighted yellow row represents the approximate ratio of elk to deer that is estimated to be on the landscape right now by CDOW. As a comparison, current CDOW estimates and objectives are in the table below (figure 46).

Northwest Elk and Mule Deer Numbers (DAU 1,2,6,7)		
Source	**Elk**	**Mule Deer**
Objective	42,800	125,800
Current estimate	86,700	143,000

Figure 46. Counts and Objectives for Northwest Colorado.

This comparison suggests that, given 1997 livestock numbers, the currently number of elk and deer estimated to be on the whole study area are at or above the "high threshold" for grazing sustainability. This result generally agrees with sentiment among most of the HPP committee members, and agrees with the general sentiment among the Division and thus is driving the interest in this model's application to the Northwest area.

Given the caveat that livestock numbers are currently not as high as they were in 1997, we also generated a results table based on the "Ten-Year Average" of livestock. Over the past four years, significant destocking has occurred in Northwest Colorado as a result of drought, and because some landowners are switching operations over to wildlife outfitting or no longer stocking their ranges. Figure 47, below, depicts the results with every variable staying the same except for the livestock numbers. The ten-year average of livestock numbers was about 84% of the 1997 high.

Mean Precipitation, Whole Study Area, 16000 Pronghorn, Livestock Ten-year Average, 12 months livestock, 6 months wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	203717	412647	621577	100
10	16518	33458	50398	148662	301122	453582	90
20	27780	56270	84761	111120	225080	339044	80
30	35952	72824	109697	83876	169898	255923	70
40	42148	85375	128602	63222	128063	192903	60
50	47012	95226	143441	47012	95226	143441	50
60	50938	103179	155420	33925	68717	103510	40
70	54146	109679	165211	23229	47052	70876	30
80	56851	115157	173463	14213	28789	43366	20
90	59146	119805	180464	6565	13298	20032	10
100	61115	123794	186473	0	0	0	0

Figure 47. Results Table based on Ten-Year Average Livestock.

Given the additional forage that is not used by livestock and available for wildlife to produce figure 47, the interpretation of the results is different. Now, instead of being at the high threshold, the actual counts depicted in figure 46 are more in line with the midpoint thresholds, which roughly equates to a sustainable level of forage consumption across the landscape. Livestock offtake in Northwest Colorado varies greatly with climatic conditions and other factors. Given this variability, we can conclude that wild ungulate numbers are between sustainable and unsustainable (over grazing), depending on livestock offtake.

Using the results table generated in figure 45 (based on the 1997 high livestock), we can create a breakdown of how the forage was allocated across the winter range landscape.

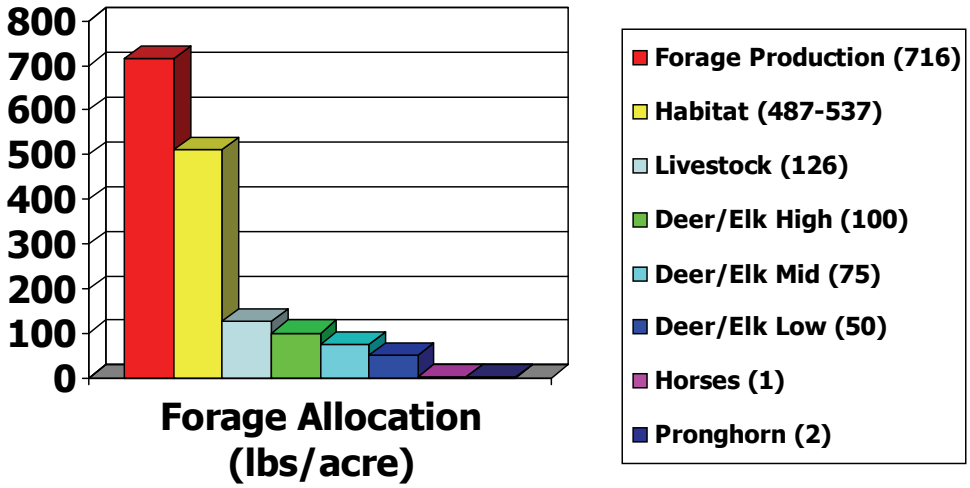


Figure 48. Forage Allocation using the results table in figure 45.

Figure 48 depicts the amount of forage that is allocated to each forage utilization component in the model. Across the landscape, the average forage production was 716 pounds per acre. The habitat retained between 487 and 537 to insure sustainability. Livestock (high for 1997) consumed 126 pounds per acre, and deer and elk numbers varied by the threshold level.

The model also has available menu options to run on the all the DAUs and GMUs in the study area. Each of these model results can be compared to the objective and count numbers in each unit. Figures 49 and 50 below represent just two of the many examples of output tables for smaller areas in the study area. Figure 49 is for DAU 2, and Figure 50 is for DAU 7.

Mean Precipitation, DAU2, 6000 Pronghorn, Livestock Ten-year Average, 12 months livestock, 6 months wildlife

%Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	%Deer
0	0	0	0	44881	99926	154971	100
10	3639	8102	12565	32751	72918	113085	90
20	6120	13626	21132	24480	54504	84528	80
30	7921	17635	27350	18480	41142	63808	70
40	9286	20674	32063	13929	31011	48095	60
50	10357	23060	35763	10357	23060	35763	50
60	11222	24986	38749	7474	16641	25807	40
70	11929	26560	41190	5118	11394	17671	30
80	12525	27886	43248	3131	6972	10812	20
90	13030	29012	44993	1446	3220	4994	10
100	13464	29978	46491	0	0	0	0

Figure 49. Sample results for DAU 2.

Mean Precipitation, DAU7, 2000 Pronghorn, Livestock Ten-year Average, 12 months livestock, 6 months wildlife

%Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	%Deer
0	0	0	0	138104	252030	365955	100
10	11198	20435	29672	100782	183915	267048	90
20	18832	34368	49903	75328	137472	199612	80
30	24373	44478	64584	56862	103767	150674	70
40	28573	52144	75715	42860	78216	113573	60
50	31870	58161	84451	31870	58161	84451	50
60	34532	63018	91504	22998	41970	60942	40
70	36707	66988	97268	15747	28738	41728	30
80	38541	70334	102127	9635	17584	25532	20
90	40096	73172	106249	4451	8122	11794	10
100	41431	75609	109787	0	0	0	0

Figure 50. Sample results for DAU 7.

Many additional results tables can be generated based on committee needs and interests. With all the variables in the model, very fine scale questions can be answered and management objectives can hopefully be equally attuned.

Appendix 4. San Luis Valley Habitat Assessment Model Case Study

A. Location

The San Luis Valley study area comprises slightly more than 4.8 million acres in the south-central part of Colorado. The San Luis Valley study area includes two HPP committee boundaries: San Luis Valley and Mount Blanca. The are includes DAUs 26, 31, 35, 36, and 37, and eight GMUs.

The study area includes all or parts of Saguache, Alamosa, Costilla, Conejos, RioGrande, Mineral, and Hinsdale counties. In addition to significant amounts of privately owned land, the study area contains lands administered by the BLM, USFS, NPS, CDOW, and other state and local agencies.

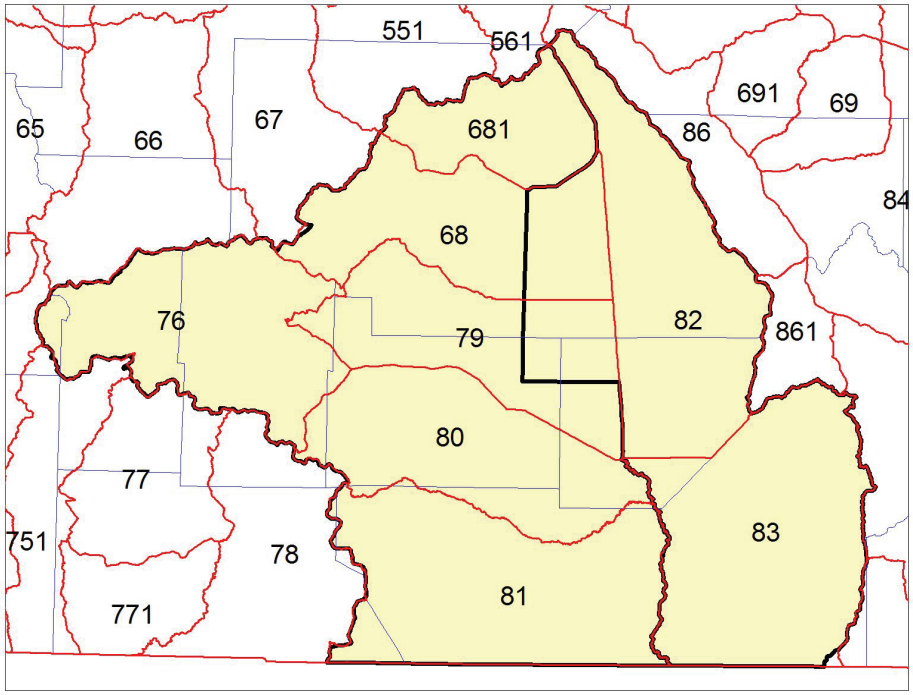


Figure 51. GMUS (red and numbered) for the San Luis Valley Study Area. HPP boundaries are in black. County boundaries are blue.

B. Project Partners

Participants involved in the project include the Habitat Model design team and the San Luis Valley and Mount Blanca Habitat Partnership Committees. The design team consists of the following personnel: Gary Wockner- Research Associate and Modeler, Randy Boone - Research Scientist, Tim Davis- HPP Coordinator and Technical Advisor, N.T. Hobbs- Principal Investigator. In addition to the design team, all members of both HPP

committees were involved in creating the model, a process which took place over several meetings and presentations in the valley. Rick Basagoitia, CDOW Area Wildlife Manager, served as the primary contact with the design team. Ron Rivile, Brent Woodwoard, and Scott Wait assisted in providing data and expertise. Rick is the CDOW staffer who will be running and implementing the model for the two HPP committees.

C. Data Sources

The San Louis Valley project was the fourth field application for the Habitat Model. Highly contentious issues surround the management of elk in the valley, specifically around Great Sand Dunes National Park, and thus provided new challenges for the model and design team. The data sources below represent the best fit for the needs of the model.

1. Production Values

Production values for the San Luis Valley study area are composed of a combination of USDA-NRCS SSURGO and STATSGO data (described in Section III of this manual) and are modified by local knowledge. SSURGO data exists for much of the study area except in land owned by the USFS in the higher elevations of the area. SSURGO data exists for most of the elk and deer winter range which is the primary interest of the model application. The image below depicts the production map for the area where the finer-resolution polygons in the center part of the valley are from SSURGO data and the coarse-resolution polygons on the mountainous fringes are from STATSGO data.

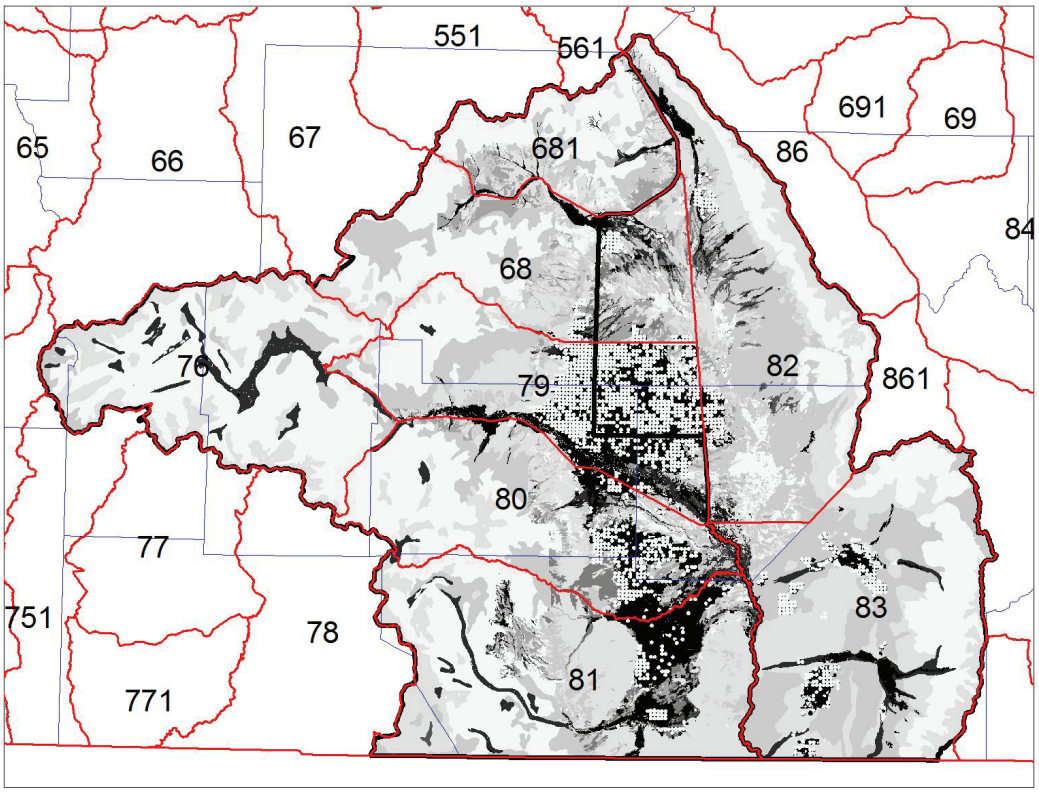


Figure 52. Production map for the San Luis Valley.

2. Winter Range Polygons

The winter range polygons for the two San Luis Valley HPP committee areas had recently been revised as part of the CDOW WRIS mapping project. Upon discussion with the HPP committee members, it was decided that the WRIS winter range polygons were accurate for the area and no further modification was necessary. Of the approximately 4.8 million acres of in the study area, about 1.8 million are elk and deer winter range. The HPP committees wanted to create two winter range options in the model—one that included all winter range, and another that only included winter range above 7800 feet elevation. The map below depicts the two winter range areas. Striped areas include all winter range, and horizontally striped areas only include winter above 7800 feet.

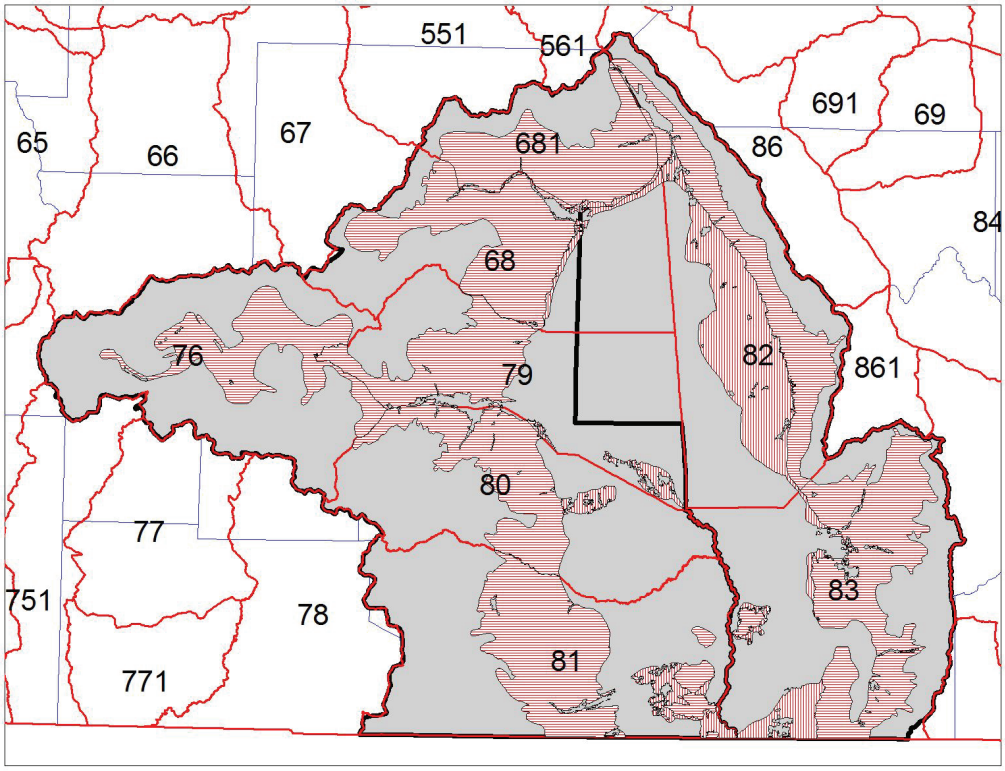


Figure 53. Red areas are elk and deer winter range.

3. Other Wild Ungulate Offtake

Pronghorn antelope and bighorn sheep also live in the San Luis Valley study area, with numbers currently at about 3,500 pronghorn and 1,350 bighorn sheep. Populations of both of the species are rather small and stable (compared to elk and deer), and so the committees wished to simply remove the forage that these two species consume from the study area prior to estimating elk and deer carrying capacity. The map below depicts the area that pronghorn and bighorns use—the green areas are pronghorn antelope, and the pinkish areas bighorn sheep. The forage in this area is reduced to account for pronghorn and bighorn grazing.

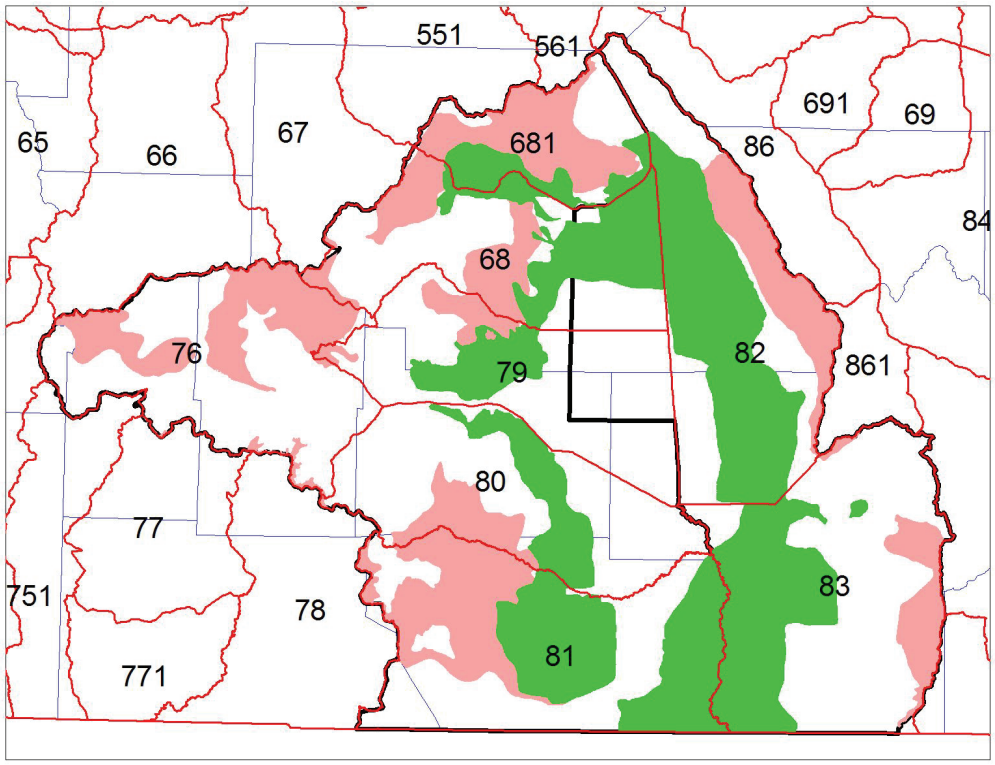


Figure 54. Pronghorn and bighorn distributions in the San Luis Valley.

4. Livestock Offtake

Like the Northwest study area, the San Luis Valley has over a hundred livestock producers. With this many producers it is unfeasible to use the procedure used in the North and Middle Park, which was to contact each producer and obtain both the number of livestock and the areas they graze.

As in the Northwest study area, livestock offtake was estimated from a more complex process. Domestic livestock numbers (cattle and sheep) were obtained from State of Colorado Agricultural Statistics documents wherein livestock numbers are reported by county for all of Colorado. Given this county-level data, livestock offtake was refined by using satellite imagery which measures the vegetation's greenness across the landscape. These satellite images have been used throughout the world to predict livestock stocking rates by correlating the greenness visible on the landscape with the productivity of the vegetation, and therefore with the number of animals that can be supported. The map below spreads the county-level livestock offtake across the landscape as predicted by the greenness seen from satellite images through the year. The shades/numbers represent offtake from 12 months of livestock grazing per year on the landscape.

As per the requests of committee members, the Habitat Model can vary livestock offtake by the number of animals grazing. The details of this variations are discussed in the Part D.

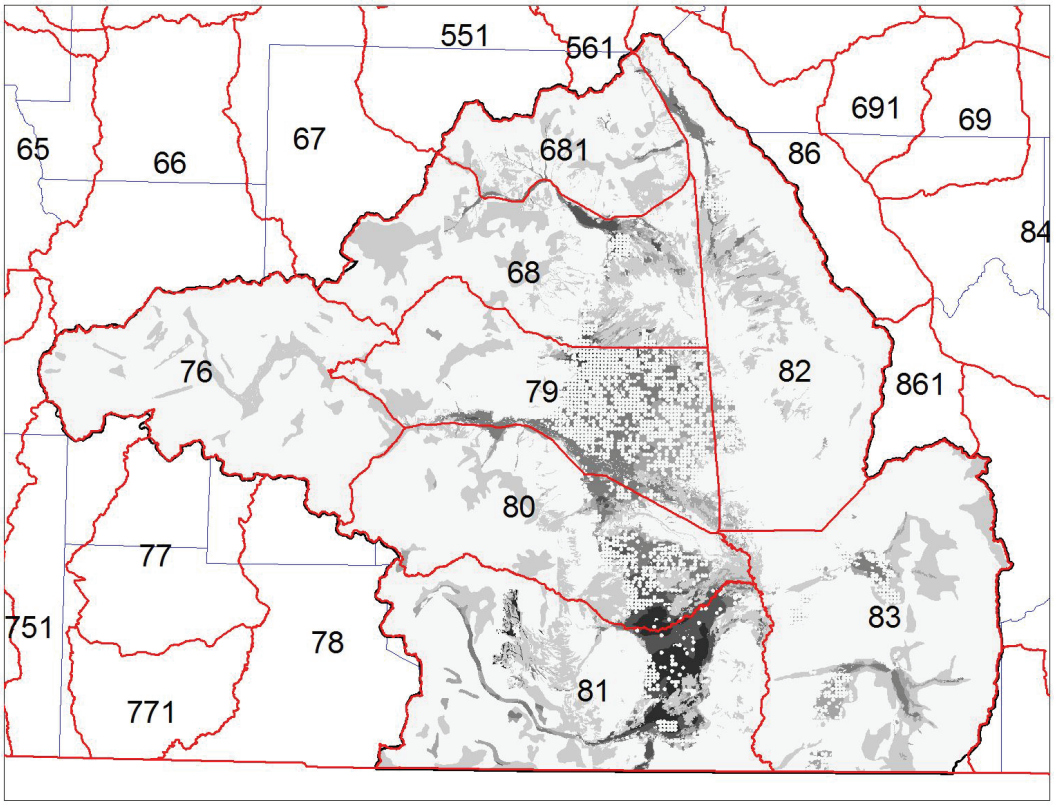


Figure 55. Livestock offtake predicted from satellite images and state statistics.

D. Model Operation

Because the San Luis Valley model operation is a bit more complicated than the stock version which was used in North and Middle Parks, this section runs the operator through the details of operating the model.

After the model is installed, the Habitat Assessment Model menu item appears at the top menu bar in ArcView.

1. To start the model, click the Habitat Assessment Model menu item, and select "Run the Model."

2. The opening dialogue box, below, will appear. Click the "OK" button.

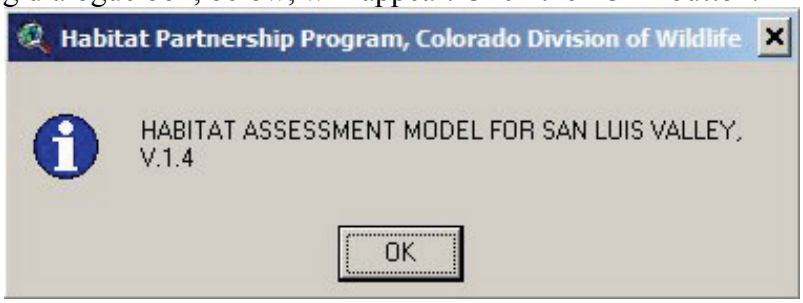


Figure 56. Opening Dialogue Box.

3. The next menu item that appears (below) asks about “Wildlife Winter Range Below 7800 feet.” The HPP committee participants wanted the option of including or not including winter range below 7800 feet.

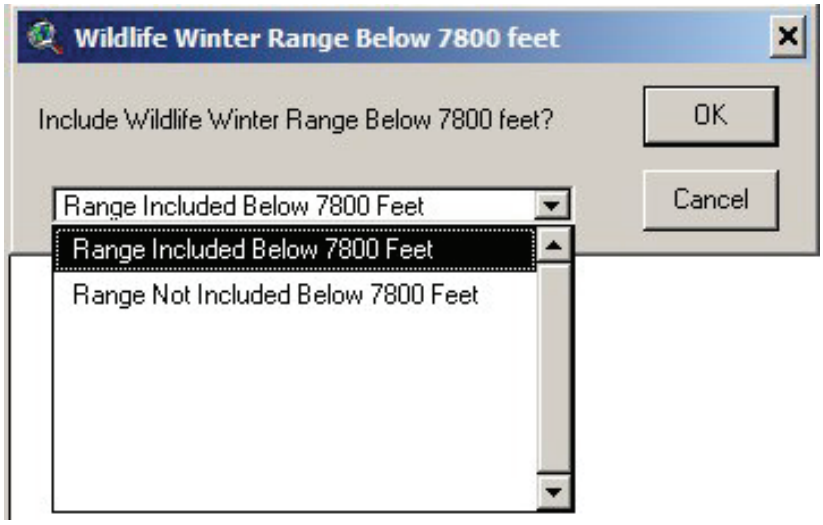


Figure 57. Winter Utilization Areas Dialogue Box.

4. The next menu item that appears (below), the “Winter Utilization Areas” allows the user to select one of thirteen winter utilization areas to be modeled. These options include wintering areas within the whole study area, all five DAUs, and all eight GMUs. This selection determines which winter range area, outlined in Section III, will be used in the modeling scenario.

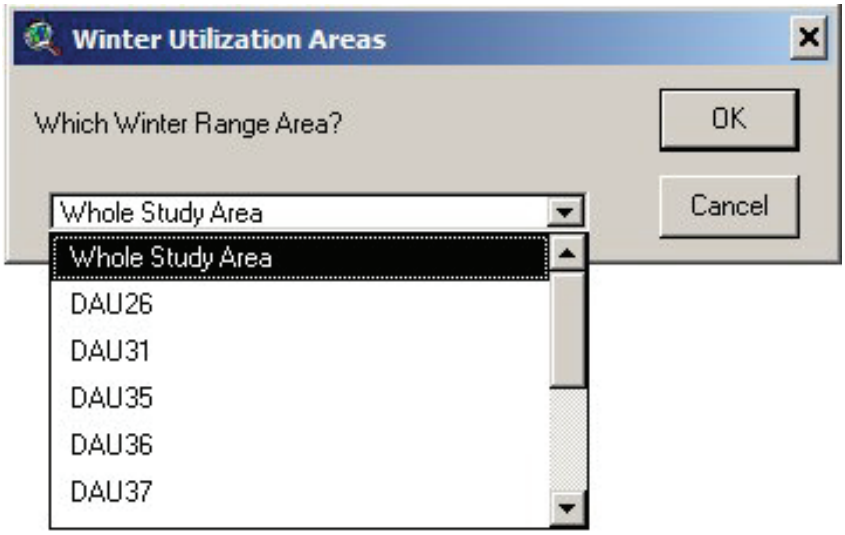


Figure 58. Winter Utilization Areas Dialogue Box.

5. The next menu choice, below, the “Prewinter Precipitation Patterns,” provides the user with three precipitation patterns. This choice determines which production values, as described in Section III, will be used for wild ungulate population estimates. Mean, dry,

and wet precipitation patterns correspond with average, below average, and above average forage production.

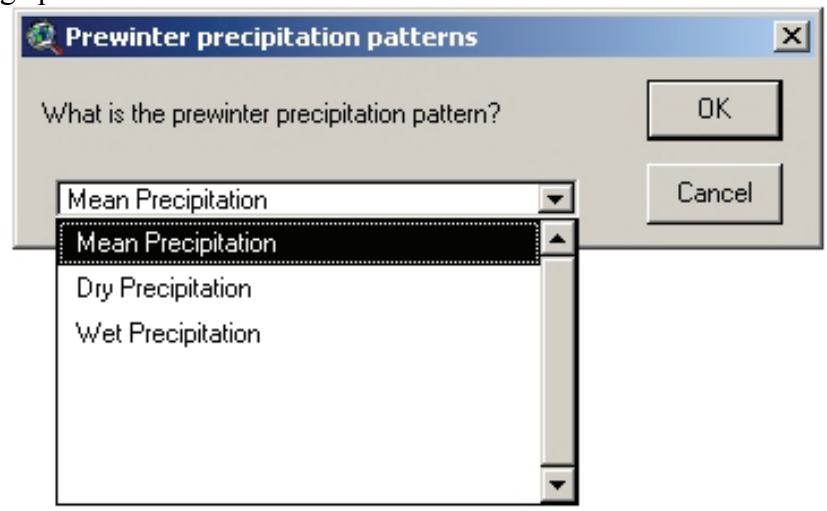


Figure 59. Prewinter Precipitation Dialogue Box.

6. The next choice (Figure 60) is the "Livestock Grazing Intensity." Two choices are available, the "Livestock High in 1997," and "Livestock Ten-Year Average." Over the past four years, significant destocking has occurred in the San Luis Valley as a result of drought and other factors. Thus, the "Ten-Year Average" represents a smaller number of livestock on the landscape (about 83% of the high in 1997). The high in 1997, on the other hand, might represent a historically high number of livestock that could be run on the landscape.

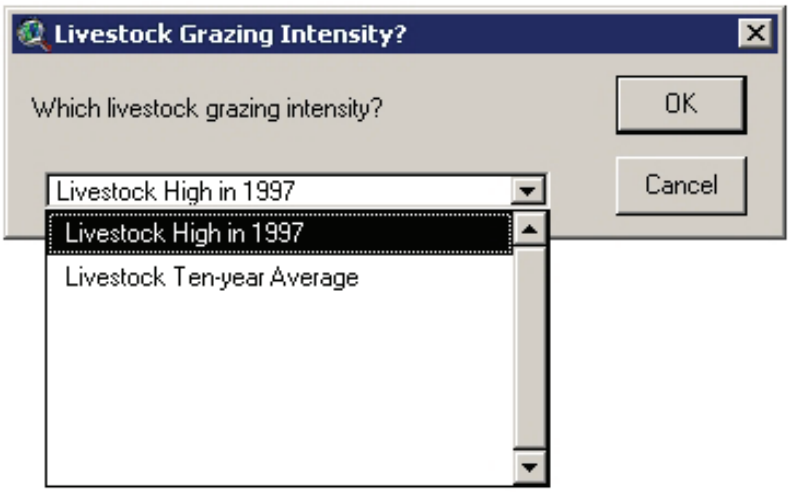


Figure 60. Livestock Grazing Intensity Dialogue Box.

6. The next menu item, "Baca Subdivision," asks whether the user wants to include the forage in the Baca Subdivision in the carrying capacity calculation for elk and deer. Because this subdivision is in small parcels, and because the landowners may not want elk and deer foraging on their lots, this options makes available the inclusion or exclusion

of the forage in that area. If the user picks a DAU or GMU that does not include the Baca Subdivision, this dialogue box does not appear.

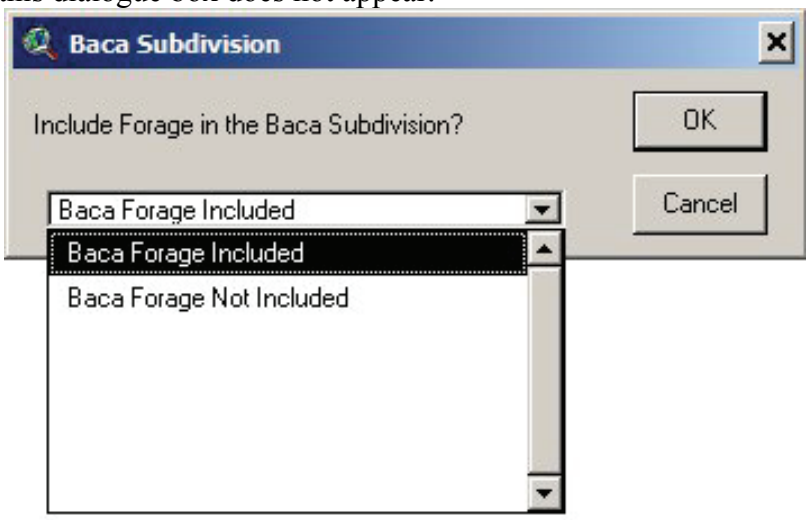


Figure 61. Baca Subdivision Dialogue Box.

7. The "Elk and Deer Utilization Period,"—the next menu item, below—allows the user to determine how many months per year elk and deer are using the chosen study area. For the whole study area, it appears that "6 months" is the most likely scenario. But, on smaller GMUs here and there, differences may occur.

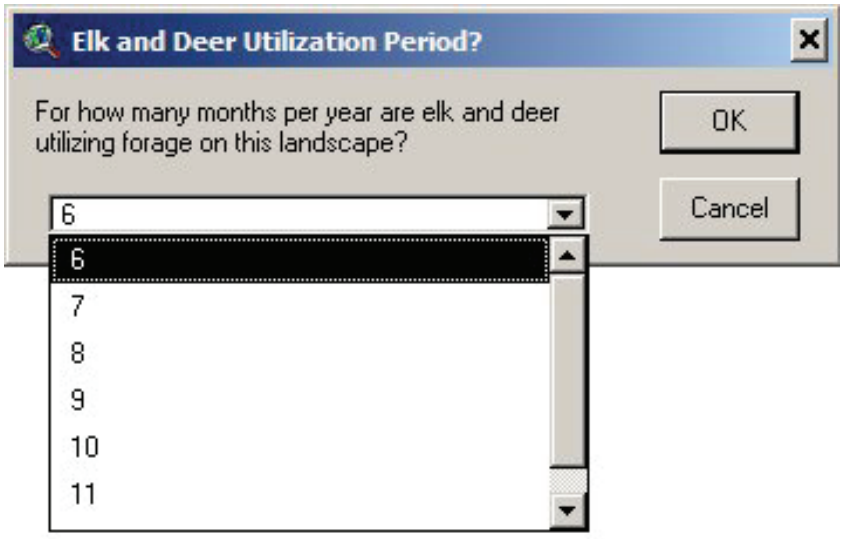
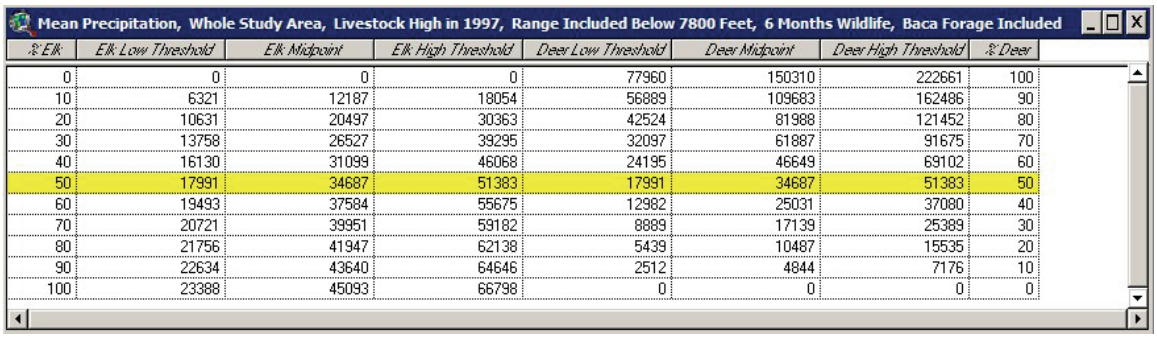


Figure 62. Elk and Deer Utilization Period Dialogue Box.

E. Habitat Model Results for the San Luis Valley Colorado

Because the Habitat Model in the San the Valley has been developed to run for multiple committees, numerous DAUs/GMUs, and with several variables, a few hundred different results tables can be generated. In the discussion below we present a few of the potential results tables with some associated interpretation.

One of the biggest questions the committees face is about the overall herd in the whole study area. In figures 63 and 64 two results are given with options that offer different ways to answer this question.



Mean Precipitation, Whole Study Area, Livestock High in 1997, Range Included Below 7800 Feet, 6 Months Wildlife, Baca Forage Included

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	77960	150310	222661	100
10	6321	12187	18054	56889	109683	162486	90
20	10631	20497	30363	42524	81988	121452	80
30	13758	26527	39295	32097	61887	91675	70
40	16130	31099	46068	24195	46649	69102	60
50	17991	34687	51383	17991	34687	51383	50
60	19493	37584	55675	12982	25031	37080	40
70	20721	39951	59182	8889	17139	25389	30
80	21756	41947	62138	5439	10487	15535	20
90	22634	43640	64646	2512	4844	7176	10
100	23388	45093	66798	0	0	0	0

Figure 63. Sample Results for the Whole Study Area specified by the table title.

Figure 63, above, offers results that are specified in the title of the table. Each of the variables in the title can be manipulated by the model, but overall, the committees have agreed that the above results may represent the most likely scenario that approximates current conditions in the San Luis Valley. One caveat is that Figure 63 is generated for "Livestock High in 1997," whereas actual livestock numbers may be lower. (To address this caveat, the results table in figure 64 was generated for the "Livestock Ten-Year Average.") The highlighted yellow row in Figure 63, above, represents the approximate ratio of elk to deer that is estimated to be on the landscape right now by CDOW (50/50). As a comparison, current CDOW estimates are that roughly 30,000 elk and 30,000 deer live in the San Luis Valley.

This comparison suggests that, given 1997 livestock numbers, the currently number of elk and deer estimated to be on the whole study area are at or below the "Middle Threshold" for grazing sustainability. This result generally agrees with sentiment among most of the HPP committee members, and agrees with the general sentiment among the Division staff. It is generally agreed upon that the conflicts arising in the San Luis Valley are due to distributional problems of grazing ungulates, rather than due to a total overabundance of animals.

Given the caveat that livestock numbers are currently not as high as they were in 1997, we also generated a results table based on the "Ten-Year Average" of livestock. Over the past four years, some destocking has occurred in the valley as a result of drought and other activities. Figure 64, below, depicts the results with every variable staying the same

except for the livestock numbers. The ten-year average of livestock numbers was about 83% of the 1997 high.

Mean Precipitation, Whole Study Area, Livestock Ten-year Average, Range Included Below 7800 Feet, 6 Months Wildlife, Baca Forage Included

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	149138	221488	293839	100
10	12092	17959	23825	108828	161631	214425	90
20	20337	30203	40069	81348	120812	160276	80
30	26320	39088	51857	61405	91192	120982	70
40	30856	45825	60794	46284	68738	91191	60
50	34416	51113	67809	34416	51113	67809	50
60	37291	55381	73472	24836	36884	48932	40
70	39640	58870	78100	17006	25255	33505	30
80	41620	61811	82002	10405	15453	20501	20
90	43299	64305	85311	4806	7138	9470	10
100	44741	66446	88152	0	0	0	0

Figure 64. Results Table based on Ten-Year Average Livestock.

Given the additional forage that is not used by livestock and available for wildlife to produce figure 64, the interpretation of the results is different. Now, instead of being at just below the middle threshold, the actual counts (30,000 elk, 30,000 deer) are just below the low thresholds. Livestock offtake in the San Luis Valley varies greatly with climatic conditions and other factors. Given this variability, we can conclude that grazing intensity across the landscape from livestock and wild ungulate is definitely at or below carrying capacity. And, we can restate the previous conclusion that conflicts arising in the San Luis Valley are due to distributional problems of grazing ungulates, rather than due to a total overabundance of animals.

Using the results table generated in figure 63 (based on the 1997 high livestock), we can create a breakdown of how the forage was allocated across the winter range landscape.

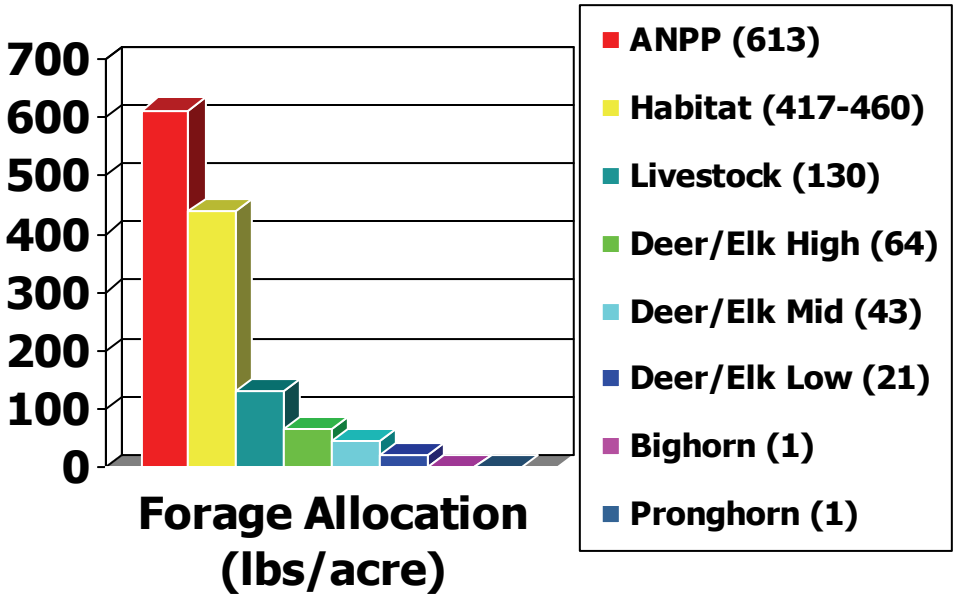


Figure 65. Forage Allocation using the results table in figure 63.

Figure 65 depicts the amount of forage that is allocated to each forage utilization component in the model. In the winter range, the average forage production was 613 pounds per acre. The habitat retained between 417 and 460 to insure sustainability. Livestock (high for 1997) consumed 130 pounds per acre, and deer and elk offtake varied by the threshold level.

The model also has available menu options to run on all the DAUs and GMUs in the study area. Each of these model results can be compared to the Division's objective and estimates in each unit. Figures 66 and 67 below represent just two of the many examples of output tables for smaller areas in the study area. Figure 66 is for DAU 37, a place where much of the conflict in the valley originates. Figure 67 is for DAU 26.

Mean Precipitation, DAU37, Livestock High in 1997, Range Included Below 7800 Feet, 6 Months Wildlife, Baca Forage Included

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	24189	37066	49943	100
10	1961	3005	4049	17649	27045	36441	90
20	3298	5054	6810	13192	20216	27240	80
30	4269	6541	8814	9960	15260	20563	70
40	5005	7669	10333	7508	11504	15500	60
50	5582	8554	11525	5582	8554	11525	50
60	6048	9268	12488	4028	6172	8317	40
70	6429	9852	13274	2758	4227	5695	30
80	6750	10344	13938	1688	2586	3485	20
90	7023	10761	14500	780	1194	1610	10
100	7257	11120	14983	0	0	0	0

Figure 66. Sample results for DAU 37.

Mean Precipitation, DAU26, Livestock High in 1997, Range Included Below 7800 Feet, 6 Months Wildlife, Baca N/A

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	369	16211	32052	100
10	30	1314	2599	270	11826	23391	90
20	50	2211	4371	200	8844	17484	80
30	65	2861	5657	152	6675	13198	70
40	76	3354	6632	114	5031	9948	60
50	85	3741	7397	85	3741	7397	50
60	92	4053	8014	61	2699	5337	40
70	98	4309	8519	42	1849	3655	30
80	103	4524	8945	26	1131	2236	20
90	107	4707	9306	12	522	1033	10
100	111	4863	9616	0	0	0	0

Figure 67. Sample results for DAU 26.

Many additional results tables can be generated based on committee needs and interests. With all the variables in the model, very fine scale questions can be answered and management objectives can hopefully be equally attuned.

Appendix 5. South Park Habitat Assessment Model Case Study

A. Location

The South Park study area comprises about 1.15 million acres in the central part of Colorado. The South Park study area includes one HPP committee boundary: South Park. The area includes the deer DAUs 16, 17, and 38, and the GMUs of 46, 49, 50, 461, 500, and 501.

The study area includes all or parts of Park, Jefferson, and Clear Creek Counties. In addition to significant amounts of privately owned land, the study area contains lands administered by the BLM, USFS, NPS, CDOW, and other state and local agencies.

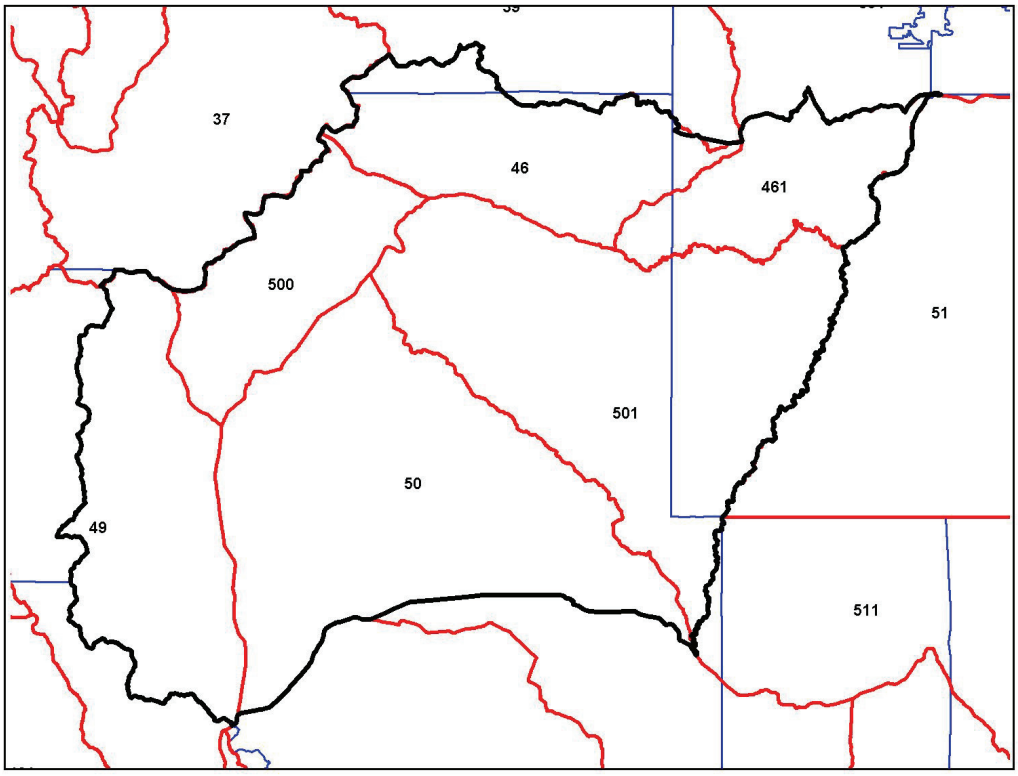


Figure 68. GMUS (red and numbered) for the South Park Study Area. HPP boundaries are in black. County boundaries are blue.

B. Project Partners

Participants involved in the project include the Habitat Model design team and the South Park committee members. The design team consists of the following personnel: Gary Wockner- Research Associate and Modeler, Randy Boone - Research Scientist, Pat Tucker – HPP Coordinator. In addition to the design team, all members of the HPP committee were involved in creating the model, a process which took place over several

meetings and presentations in South Park. Mark Lamb, CDOW District Wildlife Manager, served as the primary contact with the design team. The South Park model also had significant input from Leon Kot, John Woodward, Lawlor Walkem, and Leon Krain.

C. Data Sources

The South Park project was the fifth application of the Habitat Model and the eighth committee with which we worked. Contentious issues surround the management of elk in the Park. Specifically, elk numbers are increasing in South Park, and landowners are seeing elk in new places on their property. This is causing new concerns that the HPP committee is addressing. The data sources below represent the best fit for the needs of the model.

1. Production Values

Production values for the South Park study area are composed of USDA-NRCS STATSGO data (described in Section III of this manual) and are highly modified by local knowledge. Considerable discussion and analysis went into refining the STATSGO data, including several meetings with NRCS representatives, and analysis of irrigation and field data trends. Park-wide, the STATSGO data were lowered by 32% below the STATSGO potential; the south-center of the Park was lowered additional 30% to account for the loss of irrigation water. **This resulted in production levels on the winter range that were significantly below those used in other HPP committees in Colorado.** The image below depicts the production map for the area. The numbers represent pounds-per-acre of annual net primary production (ANPP).

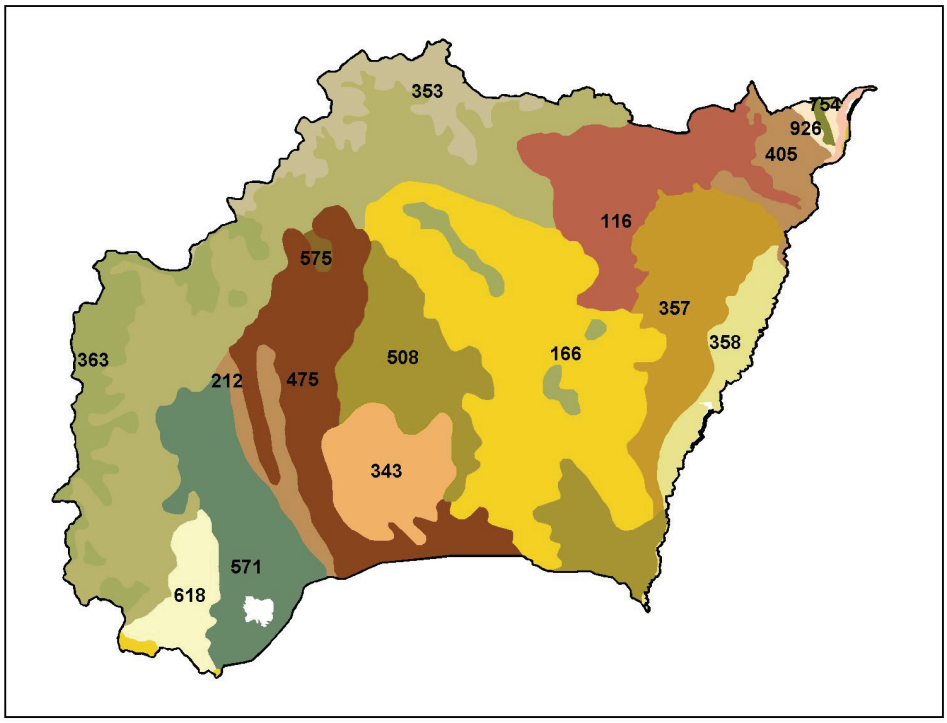


Figure 69. Production map for South Park.

2. Winter Range Polygons

The winter range polygons for the South Park HPP committee area had recently been revised as part of the CDOW WRIS mapping project. Upon discussion with the HPP committee members, it was decided that the WRIS winter range polygons were accurate for the area and no further modification was necessary. Of the approximately 1.14 million acres of in the study area, about 0.8 million are elk and deer winter range.

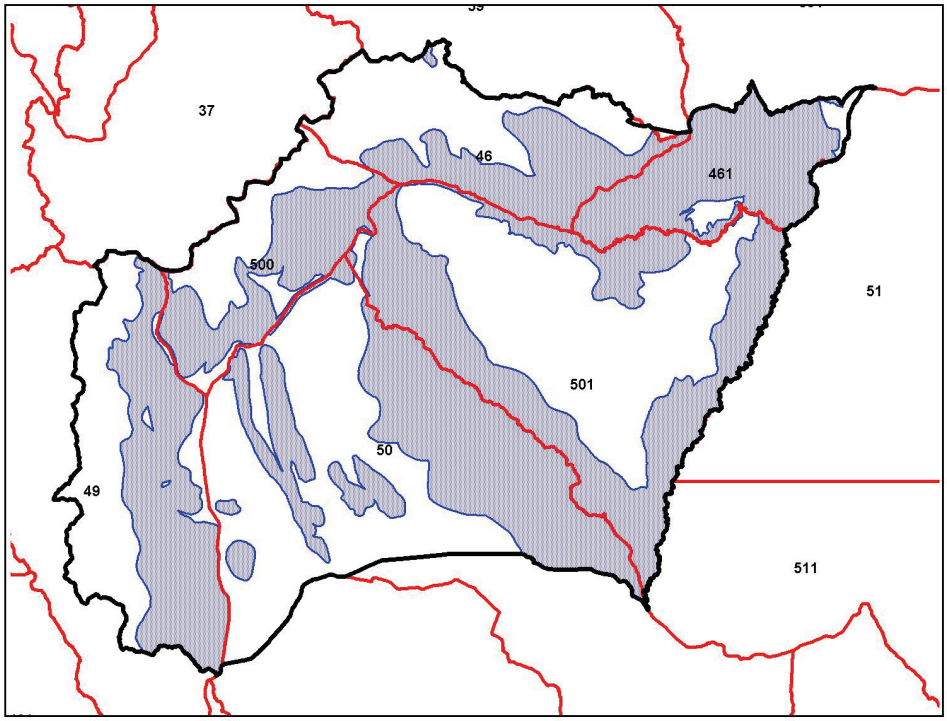


Figure 70. Blue areas are elk and deer winter range.

3. Other Wild Ungulate Offtake

Pronghorn antelope, bighorn sheep, moose, and mountain goats also live in the South Park study area, with numbers currently at about 350 Pronghorn, 340 bighorn sheep, 30 moose, and 145 mountain goats. Populations of species are rather small and stable (compared to elk and deer), and so the committees wished to simply remove the forage that these species consume from the study area prior to estimating elk and deer carrying capacity. The map below depicts the area that these species use. The forage in these areas is reduced to account for this wild ungulate grazing.

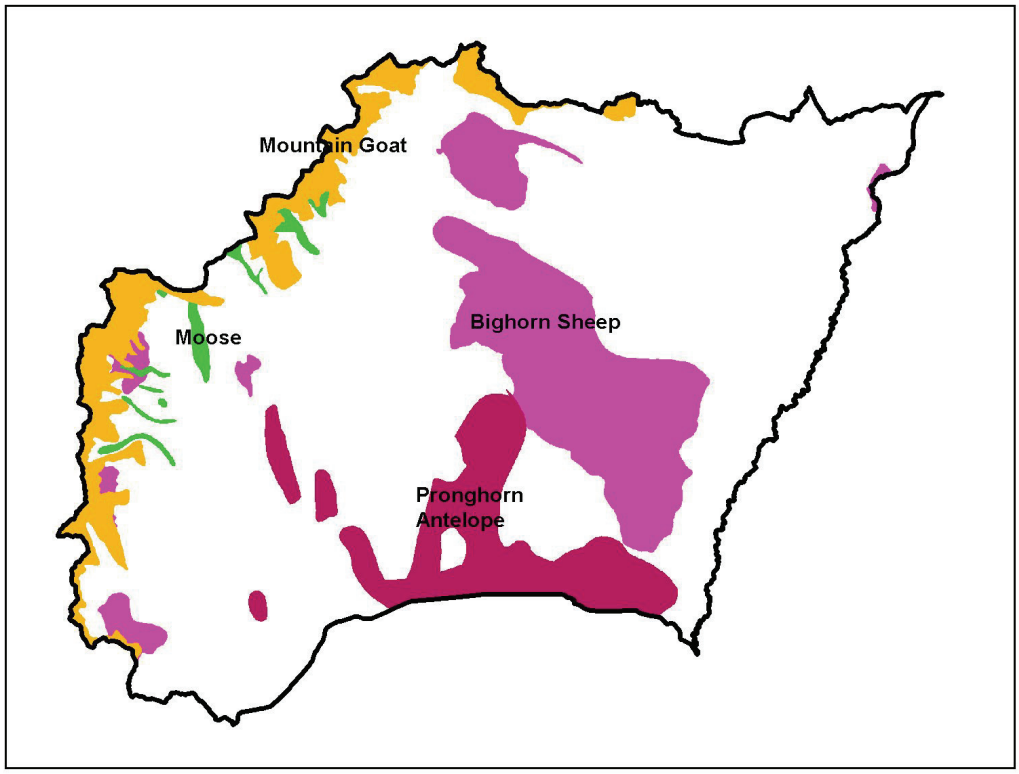


Figure 71. Pronghorn, bighorn, moose, and mountain goat distributions in South Park. Pink = bighorn sheep, maroon = pronghorn, tan = mountain goat, green = moose.

4. Livestock Offtake

South Park has many livestock producers, and thus it is unfeasible to use the procedure used in the North and Middle Park, which was to contact each producer and obtain both the number of livestock and the areas they graze.

As in the Northwest and San Luis Valley study areas, livestock offtake in South Park was estimated from a more complex process. Domestic livestock numbers (cattle and sheep) were obtained from State of Colorado Agricultural Statistics documents wherein livestock numbers are reported by county for all of Colorado. Given this county-level data, livestock offtake was refined by using satellite imagery which measures the vegetation's greenness across the landscape. These satellite images have been used throughout the world to predict livestock stocking rates by correlating the greenness visible on the landscape with the productivity of the vegetation, and therefore with the number of animals that can be supported. The map below spreads the county-level livestock offtake across the landscape as predicted by the greenness seen from satellite images through the year. The shades/numbers represent offtake from 12 months of livestock grazing per year on the landscape.

As per the requests of committee members, the Habitat Model can vary livestock offtake by the number of animals grazing. The details of this variations are discussed in the Part D.

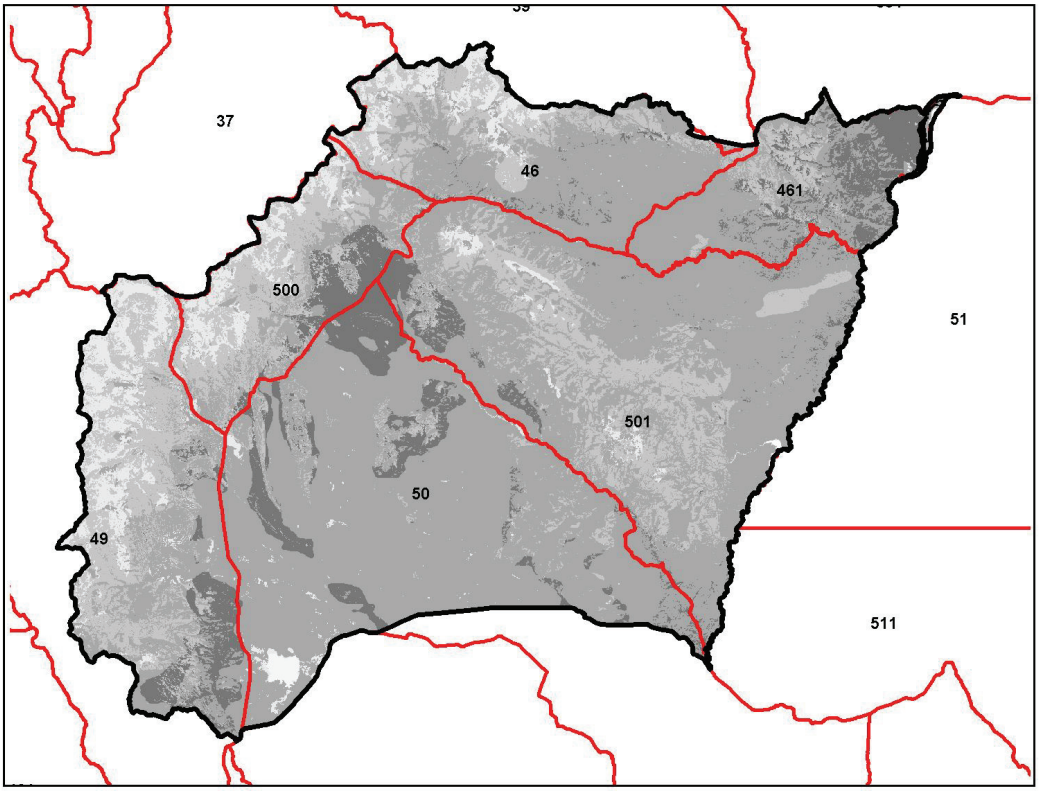


Figure 72. Livestock offtake predicted from satellite images and state statistics.

D. Model Operation

Because the South Park model operation is a bit more complicated than the stock version which was used in North and Middle Parks, this section runs the operator through the details of operating the model.

After the model is installed, the Habitat Assessment Model menu item appears at the top menu bar in ArcView.

1. To start the model, click the Habitat Assessment Model menu item, and select "Run the Model."

2. The opening dialogue box, below, will appear. Click the "OK" button.

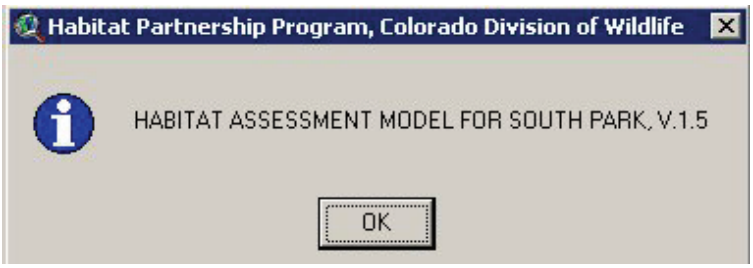


Figure 73. Opening Dialogue Box.

3. The next menu item that appears (below), the "Winter Utilization Areas" allows the user to select one of ten winter utilization areas to be modeled. These options include wintering areas within the whole study area, all three DAUs, and all six GMUs. This selection determines which winter range area, outlined in Section III, will be used in the modeling scenario.

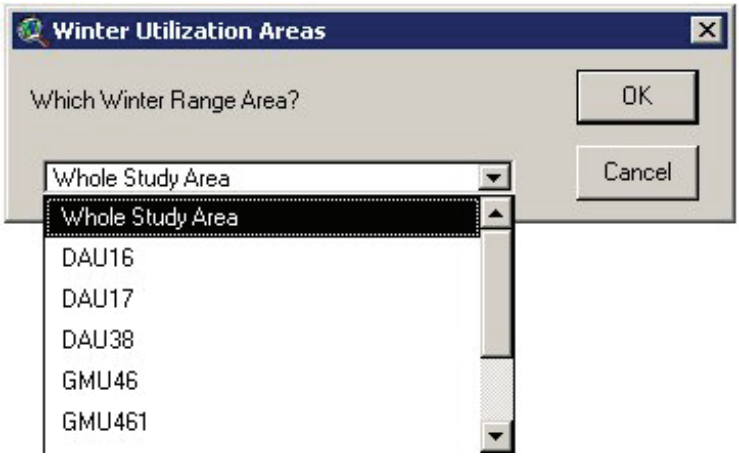


Figure 74. Winter Utilization Areas Dialogue Box.

4. The next menu choice, below, the "Prewinter Precipitation Patterns," provides the user with three precipitation patterns. This choice determines which production values, as described in Section III, will be used for wild ungulate population estimates. Mean, dry, and wet precipitation patterns correspond with average, below average, and above average forage production.

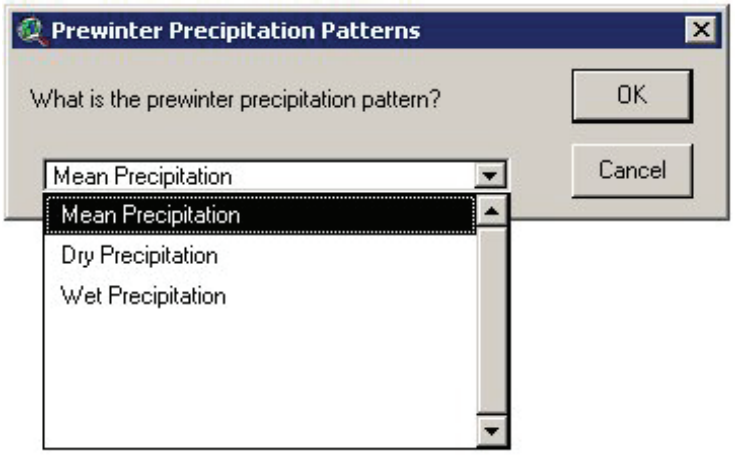


Figure 75. Prewinter Precipitation Dialogue Box.

5. The next choice (Figure 76) is the "Livestock Grazing Intensity." Three choices are available, the "Livestock High in 1997," and "Livestock Ten-Year Average," and the "Livestock Low in 2002." Over the past four years, significant destocking has occurred in South Park as a result of drought and other factors. Over the last decade, more destocking has occurred because landowners have sold their irrigation water to Front Range cities. Thus, the "Ten-Year Average" represents a smaller number of livestock on the landscape, and the "Livestock Low in 2002" is a historic low. The high in 1997, on the other hand, might represent a historically high number of livestock that could be run on the landscape.

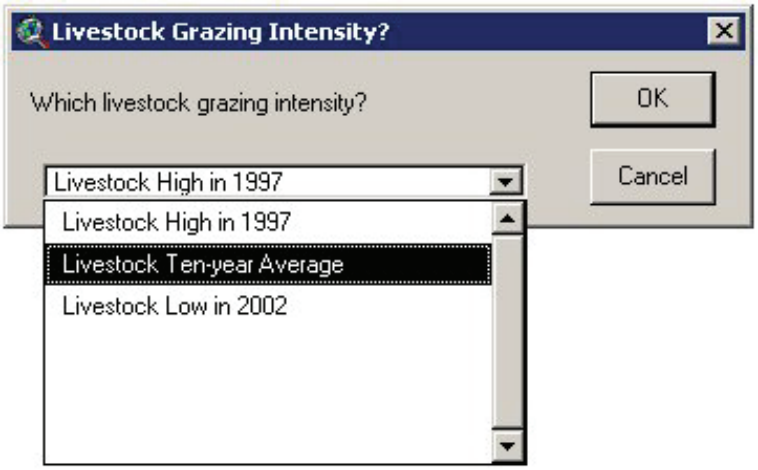


Figure76. Livestock Grazing Intensity Dialogue Box.

6. The "Elk and Deer Utilization Period,"—the next menu item, below—allows the user to determine how many months per year elk and deer are using the chosen study area. For the whole study area, it appears that "6 months" is the most likely scenario. But, on smaller GMUs here and there, differences may occur.

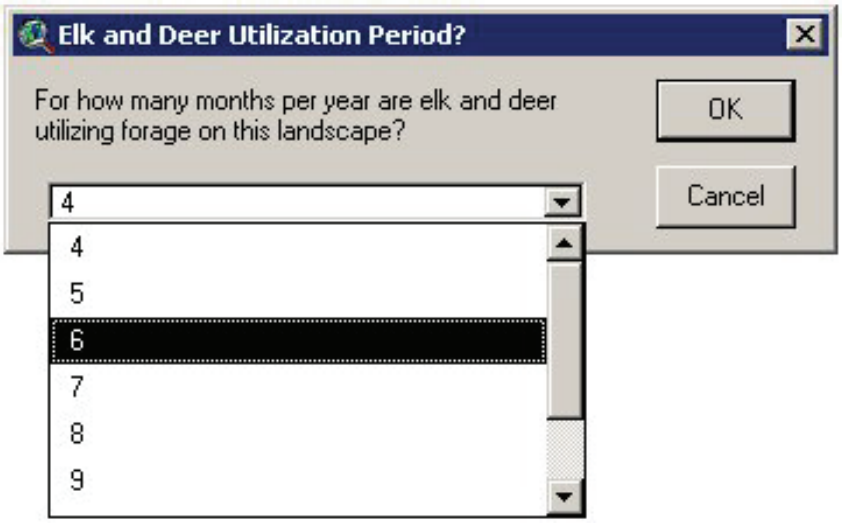
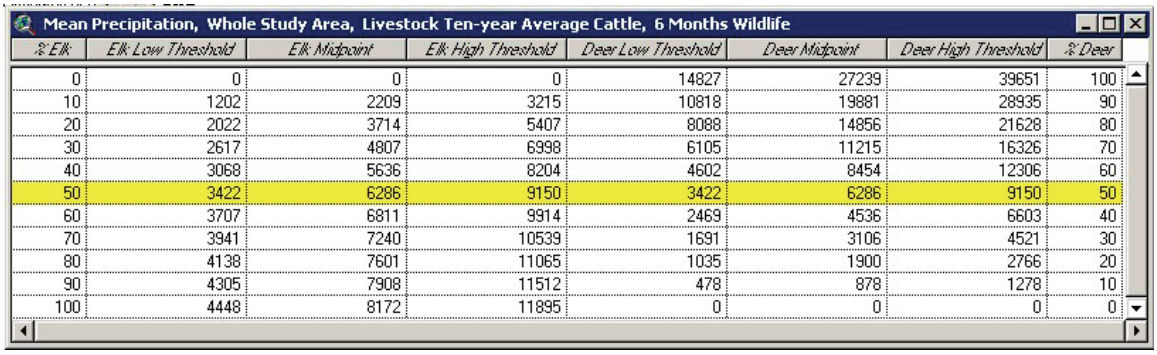


Figure 77. Elk and Deer Utilization Period Dialogue Box.

E. Habitat Model Results for South Park, Colorado

Because the Habitat Model in the South Park has been developed to run for multiple DAUs/GMUs, and with several variables, dozens of different results tables can be generated. In the discussion below we present a few of the potential results tables with some associated interpretation.

One of the biggest questions the committees face is about the overall herd in the whole study area. In figures 78 and 79 two results are given with options that offer different ways to answer this question.



Mean Precipitation, Whole Study Area, Livestock Ten-year Average Cattle, 6 Months Wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	14827	27239	39651	100
10	1202	2209	3215	10818	19881	28935	90
20	2022	3714	5407	8088	14856	21628	80
30	2617	4807	6998	6105	11215	16326	70
40	3068	5636	8204	4602	8454	12306	60
50	3422	6286	9150	3422	6286	9150	50
60	3707	6811	9914	2469	4536	6603	40
70	3941	7240	10539	1691	3106	4521	30
80	4138	7601	11065	1035	1900	2766	20
90	4305	7908	11512	478	878	1278	10
100	4448	8172	11895	0	0	0	0

Figure 78. Sample Results for the Whole Study Area specified by the table title.

Figure 78, above, offers results that are specified in the title of the table. Each of the variables in the title can be manipulated by the model, but overall, the committees have agreed that the above results may represent the most likely scenario that approximates current conditions in South Park. The highlighted yellow row in Figure 78, above, represents the approximate ratio of elk to deer that is estimated to be on the landscape right now by CDOW (50/50). As a comparison, current CDOW estimates are that roughly 3,000 elk and 3,000 deer live in South Park.

This comparison suggests that, given ten-year average livestock numbers, the currently number of elk and deer estimated to be on the whole study area are below the "Middle Threshold" for grazing sustainability. This result generally agrees with sentiment among most of the HPP committee members, and agrees with the general sentiment among the Division staff. It is generally agreed upon that the conflicts arising in South Park are due to distributional problems of grazing ungulates, rather than due to a total overabundance of animals.

Given the caveat that the South Park area has been hit hard with drought, some members of the HPP committee would prefer that CDOW set its elk and deer objectives based on the drought scenario, which allows about 30% less forage available across the landscape. When using the drought scenario, it is also more appropriate to use the "Livestock Low in 2002" which coincides with the severe drought of 2002. Figure 79, below, depicts these results.

Dry Precipitation, Whole Study Area, Livestock Low in 2002 Cattle, 6 Months Wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	8763	17877	26990	100
10	711	1449	2188	6399	13041	19692	90
20	1195	2438	3680	4780	9752	14720	80
30	1547	3155	4763	3609	7361	11112	70
40	1813	3699	5584	2720	5549	8376	60
50	2022	4125	6228	2022	4125	6228	50
60	2191	4470	6749	1459	2977	4495	40
70	2329	4752	7174	999	2039	3078	30
80	2446	4989	7532	612	1247	1883	20
90	2544	5190	7836	282	576	870	10
100	2629	5363	8097	0	0	0	0

Figure 79. Results Table based on Drought and Low Livestock.

Given the decrease in forage that is available and the lower livestock numbers, the forage available to elk and deer is lower than in Figure 78, and thus the carrying capacity estimates are also lower. These factors change the interpretation slightly. Now, instead of being below the lower threshold, the actual counts (3,000 elk, 3,000 deer) are between the low and middle thresholds. The interpretation is that if the HPP committee wants to base its carrying capacity estimates on drought conditions, then elk and deer numbers are approaching the middle threshold of carrying capacity. Still, the conflicts arising in South Park are primarily due to distributional problems of grazing ungulates, rather than due to a total overabundance of animals.

Using the results table generated in figure 78 (based on the ten-year average of livestock), we can create a breakdown of how the forage was allocated across the winter range landscape.

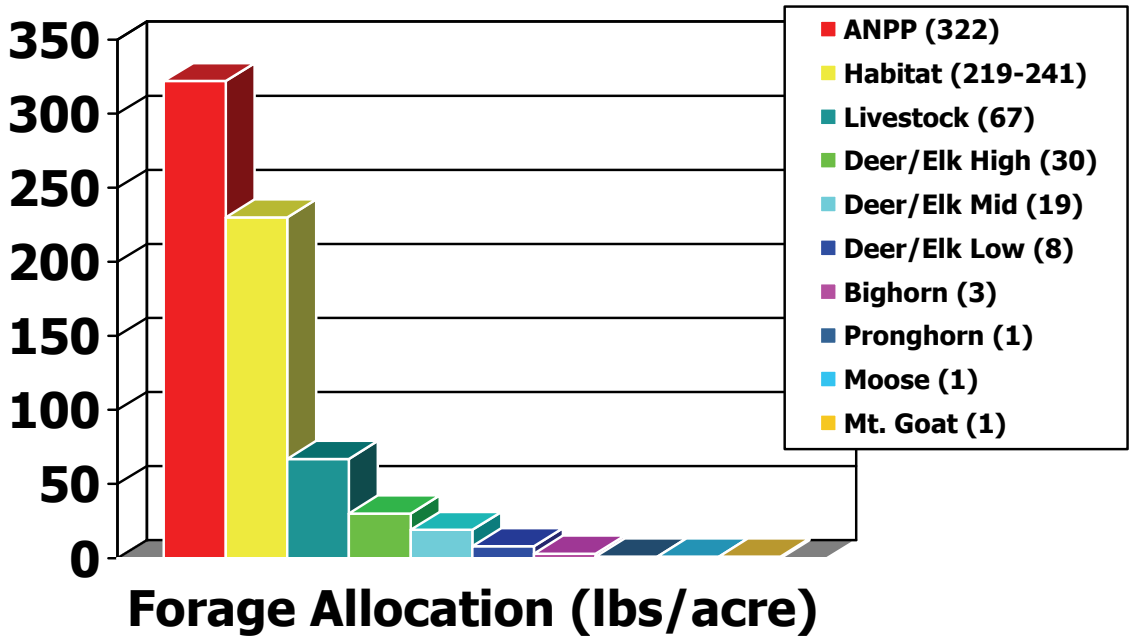


Figure 80. Forage Allocation using the results table in figure 78.

Figure 80 depicts the amount of forage that is allocated to each forage utilization component in the model. In the winter range, the average forage production was 322 pounds per acre (note: this is significantly below what has been so-far agreed upon as being available in other HPP areas in Colorado). The habitat retained between 241 and 219 to ensure sustainability. Livestock (ten-year average) consumed 67 pounds per acre (note: this is also significantly below the livestock grazing intensity in other HPP areas in Colorado), and deer and elk offtake varied by the threshold level. Given these numbers, the South Park area seems to represent a quantitatively different ecological system than has existed in the prior seven HPP committees upon which this model has been run. South Park has significantly lower forage production, and significantly lower livestock offtake.

The model also has available menu options to run on the all the DAUs and GMUs in the study area. Each of these model results can be compared to CDOW's objectives and estimates in each unit. Many additional results tables can be generated based on committee needs and interests. With all the variables in the model, very fine scale questions can be answered and management objectives can hopefully be equally attuned.

Appendix 6. Gunnison Habitat Assessment Model Case Study

A. Location

The Gunnison study area comprises about 2.29 million acres in the central part of Colorado. The Gunnison study area includes one HPP committee boundary: Gunnison. The area includes the deer DAUs 21, 22, and 25, elk DAUs 41, 43, and 25, Pronghorn DAU 23, and the GMUs of 54, 55, 551, 66, and 67.

The study area includes all or parts of Gunnison, Saguache, and Hinsdale Counties. In addition to significant amounts of privately owned land, the study area contains lands administered by the BLM, USFS, NPS, CDOW, and other state and local agencies.

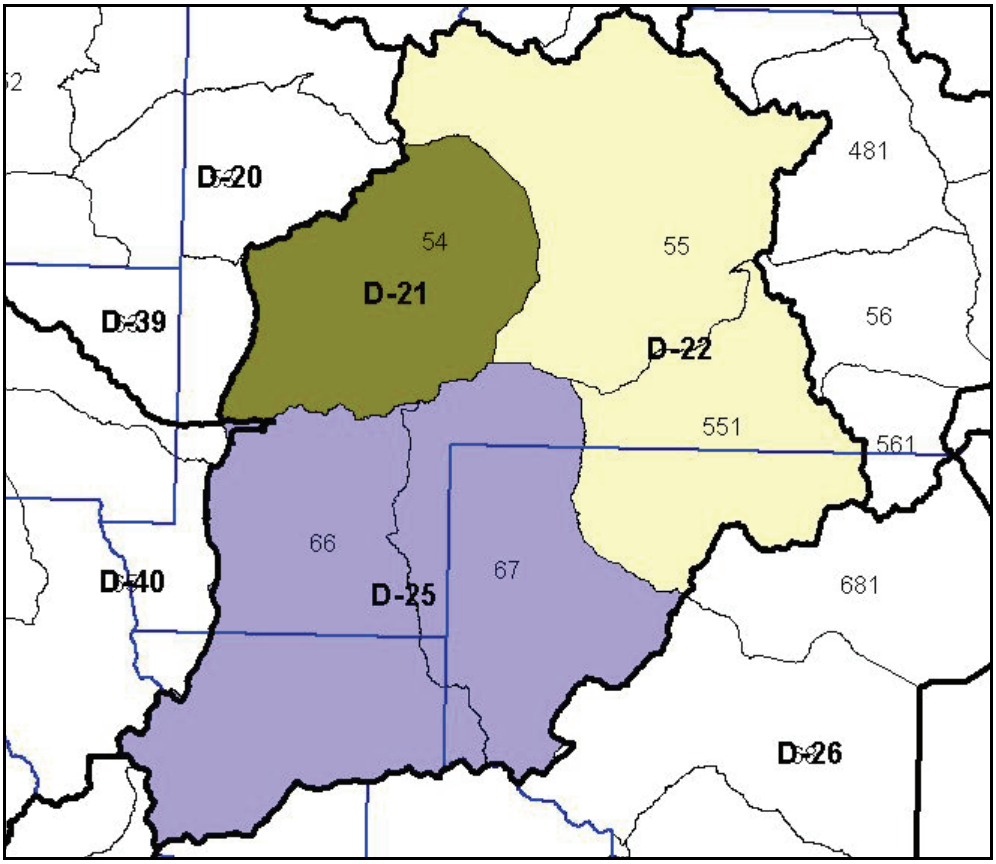


Figure 81. DAUs (bold black numbered, color-shaded), GMUs (black numbered) for the Gunnison Study Area. HPP boundaries are in black. County boundaries are blue.

B. Project Partners

Participants involved in the project include the Habitat Model design team and the Gunnison committee members. The design team consists of the following personnel: Gary Wockner- Research Associate and Modeler, Randy Boone - Research Scientist, Pat Tucker – HPP Coordinator. In addition to the design team, all members of the HPP committee were involved in creating the model, a process which took place over several meetings and presentations.

C. Data Sources

The Gunnison project was the sixth application of the Habitat Model and the ninth committee with which we worked. The management of elk and deer in the Gunnison Basin has been of ongoing concern for local managers and landowners for many years. Specifically, there is concern that elk and deer numbers are too high, and that there are large negative habitat impacts (of deer) on browse vegetation communities.

The HPP committee has ongoing activities that address these concerns. The data sources below represent the best fit for the needs of the model.

1. Production Values

Production values for the Gunnison study area are composed of USDA-NRCS SSURGO data (described in Section III of this manual) and are highly modified by local knowledge and local data sources. The USFS and the BLM offered local data that were incorporated into the model, including about 120 point samples of varied vegetation types. On a per-acre basis, the final production values represented about a 35% decrease from the SSURGO potential. Local managers also believe that the actual decrease may be even higher than the data represented. The image below depicts the production map for the area.

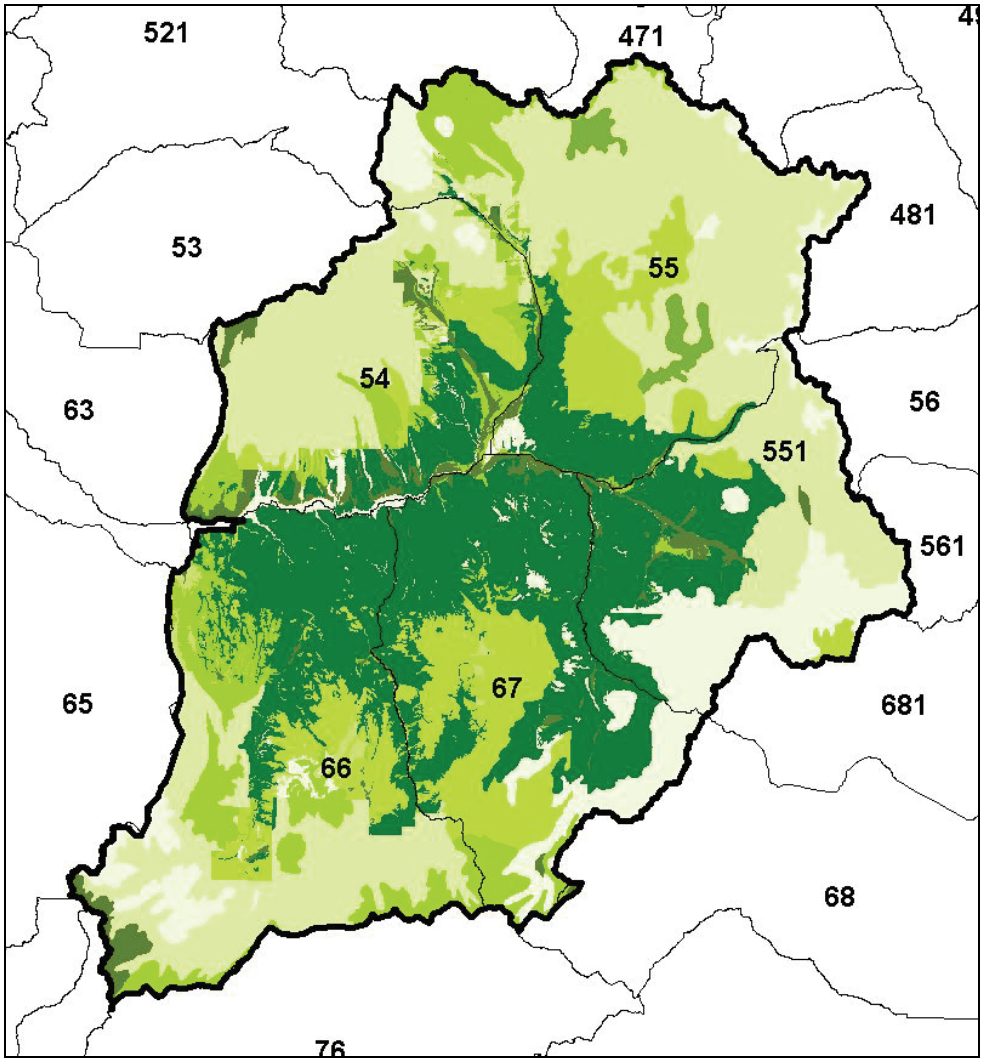


Figure 82. Production map for Gunnison HPP area. Darker green color represents higher production values.

2. Winter Range Polygons

The winter range polygons for the Gunnison HPP committee area had recently been revised as part of the CDOW WRIS mapping project. Upon discussion with the HPP committee members, it was decided that the WRIS winter range polygons were accurate for the area and no further modification was necessary. Of the approximately 2.29 million acres in the study area, about 1.06 million are elk and deer winter range.

In addition to the winter range polygons, the Gunnison committee also wanted to see results using the severe winter range polygons. Of the approximately 2.29 million acres in the study area, about 404,000 are elk and deer severe winter range. At the meetings, considerable discussion occurred around whether the winter range or severe winter range was the appropriate modeling area for elk and deer in the study area. The final model incorporates both options. The map of winter range and severe winter range is below.

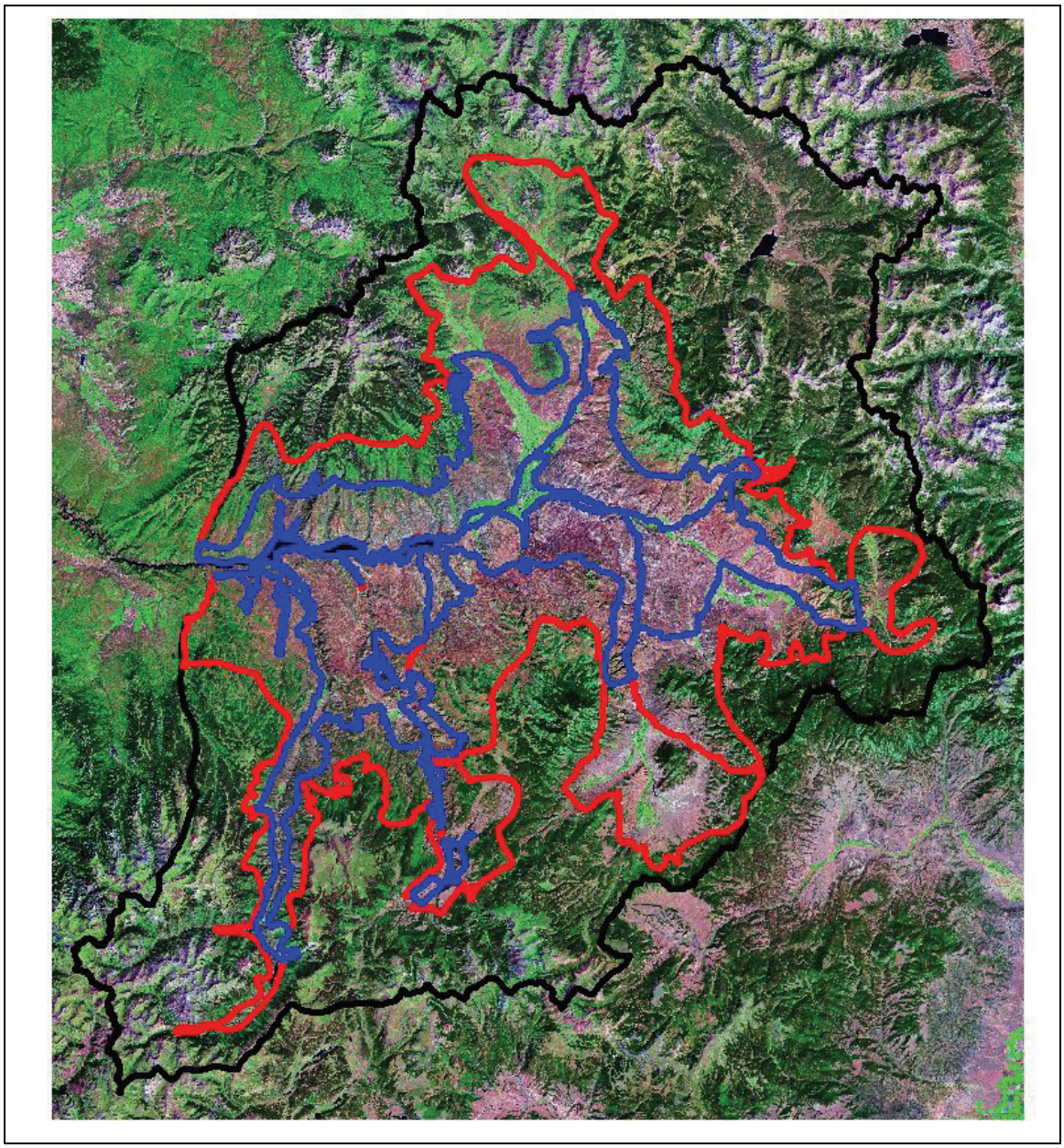


Figure 83. Red outline is elk and deer winter range. Blue outline is elk and deer severe winter range.

3. Other Wild Ungulate Offtake

Pronghorn antelope, bighorn sheep, moose, and mountain goats also live in the Gunnison study area, with numbers currently at about 450 pronghorn, 480 bighorn sheep, 105 moose, and 115 mountain goats. Populations of species are rather small and stable (compared to elk and deer), and so the committees wished to simply remove the forage that these species consume from the study area prior to estimating elk and deer carrying capacity. The map below depicts the area that these species use. The forage in these areas is reduced to account for this wild ungulate grazing.

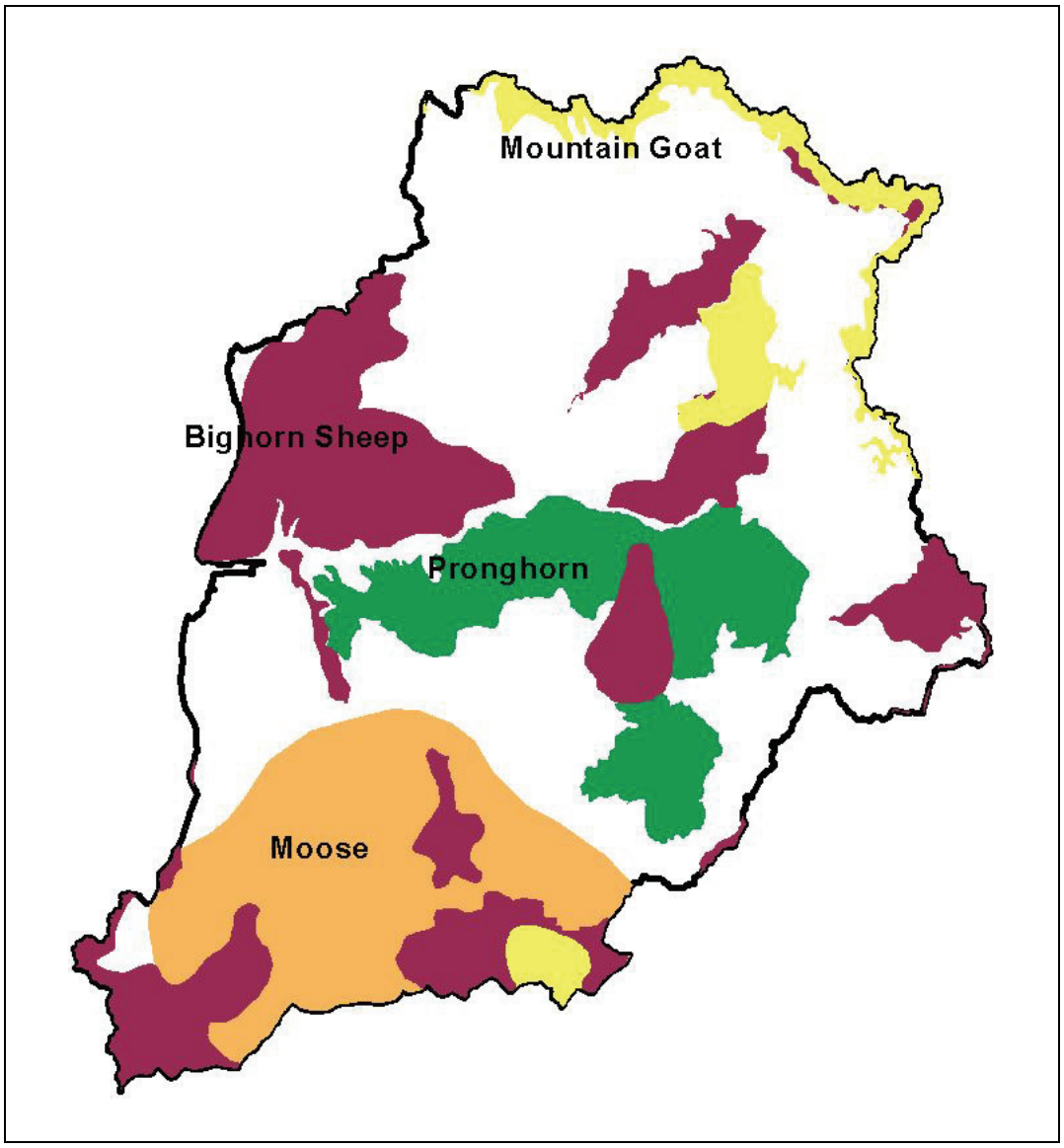


Figure 84. Pronghorn, bighorn, moose, and mountain goat distributions in the Gunnison HPP area. Maroon = bighorn sheep, green = pronghorn, tan = moose, yellow = mountain goat.

4. Livestock Offtake

Gunnison has many livestock producers, and thus it was unfeasible to use the procedure used in the North and Middle Park, which was to contact each producer and obtain maps of the areas grazed. It was feasible, however, to get current numbers of livestock from local ranchers. It was also feasible to get livestock numbers (cattle and sheep) from the State of Colorado Agricultural Statistics Service wherein livestock numbers are reported by county for all of Colorado.

Given this county-level data and the estimate from local ranchers, livestock offtake was refined by using satellite imagery which measures the vegetation's greenness across the landscape. These satellite images have been used throughout the world to predict

livestock stocking rates by correlating the greenness visible on the landscape with the productivity of the vegetation, and therefore with the number of animals that can be supported. The map below spreads the county-level livestock offtake across the landscape as predicted by forage production and the greenness seen from satellite images through the year.

As per the requests of committee members, the Habitat Model can vary livestock offtake by the number of animals grazing. The details of this variation are discussed in Part D.

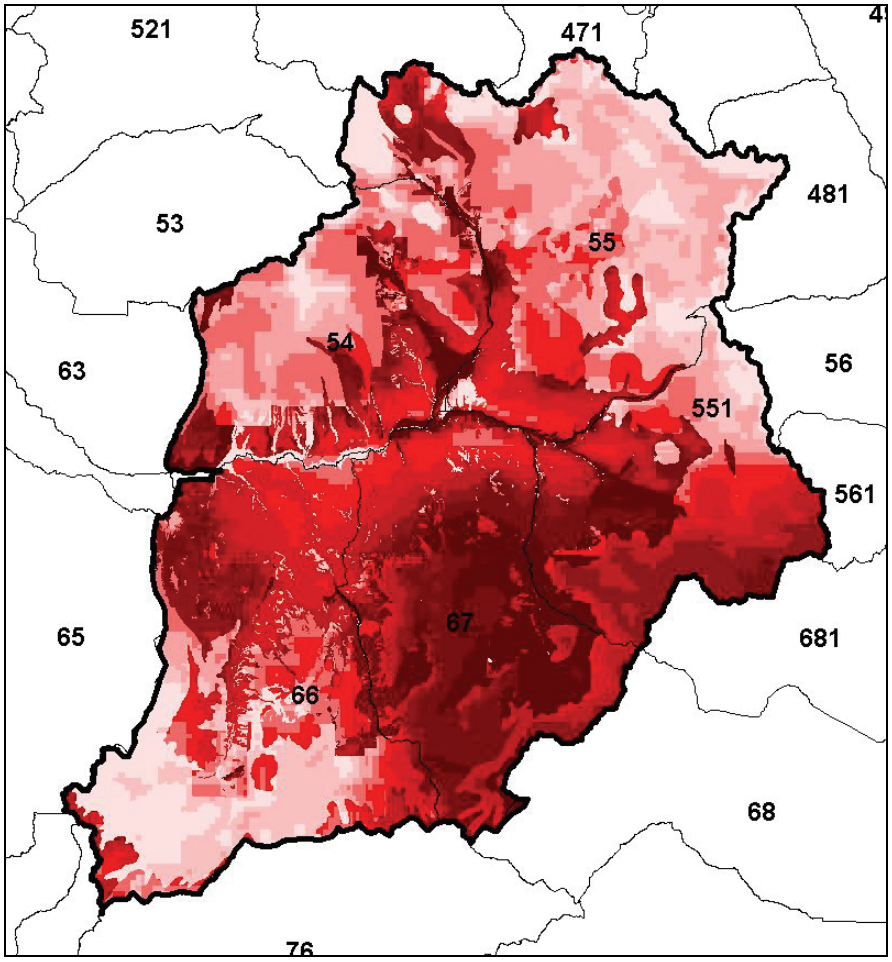


Figure 85. Livestock offtake predicted from satellite images and state statistics. The darker areas represent higher offtake. The darkest non-irrigated areas are about 85 pounds per acre of offtake.

D. Model Operation

After the model is installed (see Section VI), the Habitat Assessment Model menu item appears at the top menu bar in ArcView.

1. To start the model, click the Habitat Assessment Model menu item, and select "Run the Model."

2. The opening dialogue box, below, will appear. Click the "OK" button.

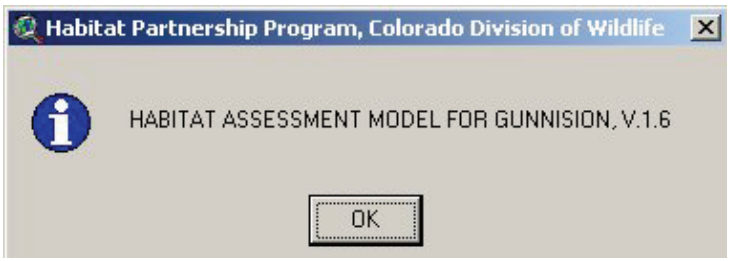


Figure 86. Opening Dialogue Box.

3. The next menu item that appears (below), the "Winter Range" or "Severe Winter Range" allows the user to select either option. As mentioned earlier, considerable discussion took place in the committee meetings about which area best represented habitat use by Gunnison big game.

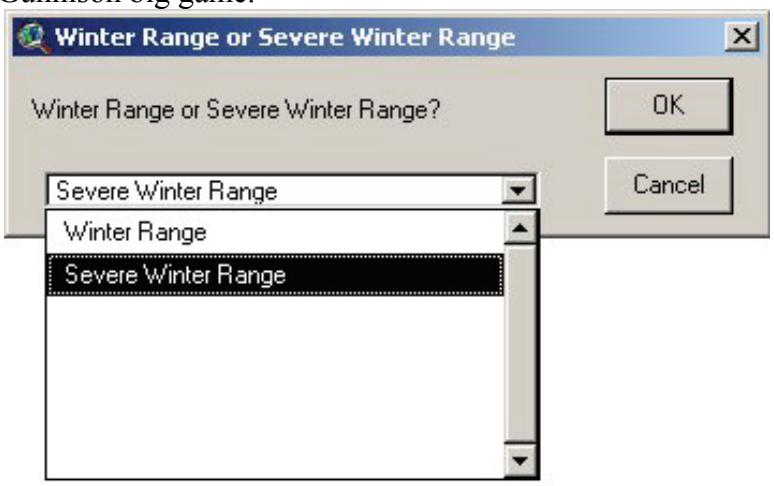


Figure 87. Winter Utilization Areas Dialogue Box.

4. The next menu item that appears (below), the "Winter Utilization Areas," allows the user to select one of nine winter utilization areas to be modeled. These options include wintering areas within the whole study area, all three DAUs, and all five GMUs. This selection determines which winter range area, outlined in Section III, will be used in the modeling scenario.

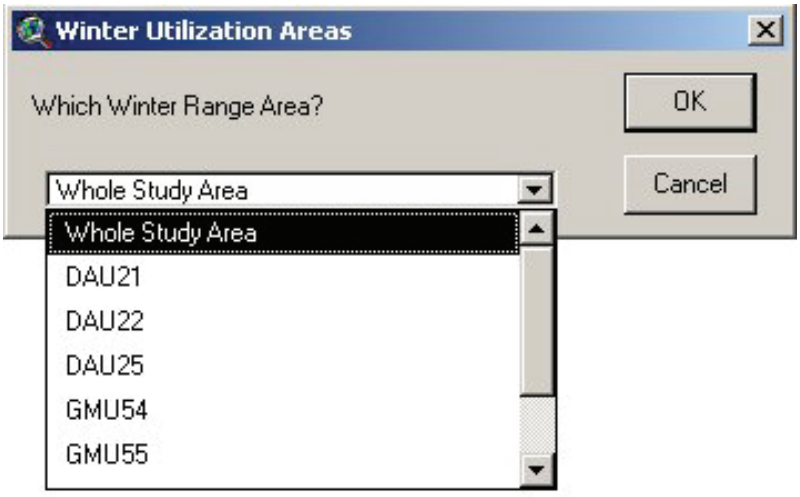


Figure 88. Winter Utilization Areas Dialogue Box.

5. The next menu choice, below, the "Prewinter Precipitation Patterns," provides the user with three precipitation patterns. This choice determines which production values, as described in Section III, will be used for wild ungulate population estimates. Mean, dry, and wet precipitation patterns correspond with average, below average, and above average forage production.

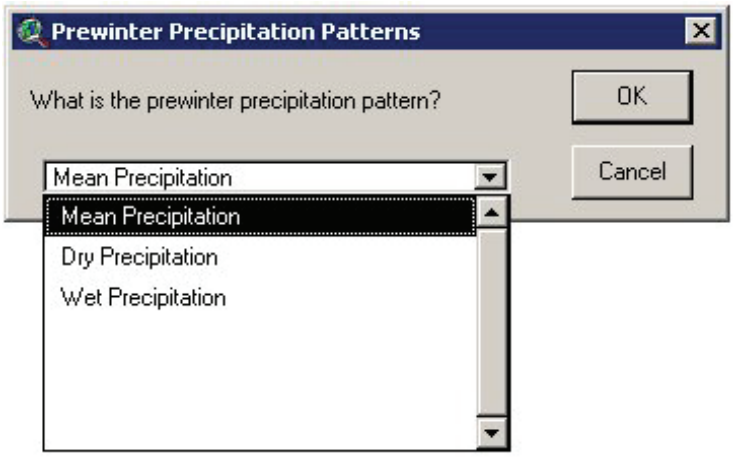


Figure 89. Prewinter Precipitation Dialogue Box.

6. The next choice (Figure 90) is the "Livestock Grazing Intensity." Four choices are available, the "Livestock High in 1997," and "Livestock Ten-Year Average," the "Livestock Low in 2002," and the "Livestock 2006." Over the past four years, some destocking has occurred in the Gunnison area as a result of drought. Thus, the "Ten-Year Average" represents a smaller number of livestock on the landscape, and the "Livestock Low in 2002" is a historic low. The high in 1997, on the other hand, might represent a historically high number of livestock that could be run on the landscape. The "Livestock 2006" is above the historic low of 2002, but below the ten-year average and based on population estimates provided to us by the Gunnison committee..

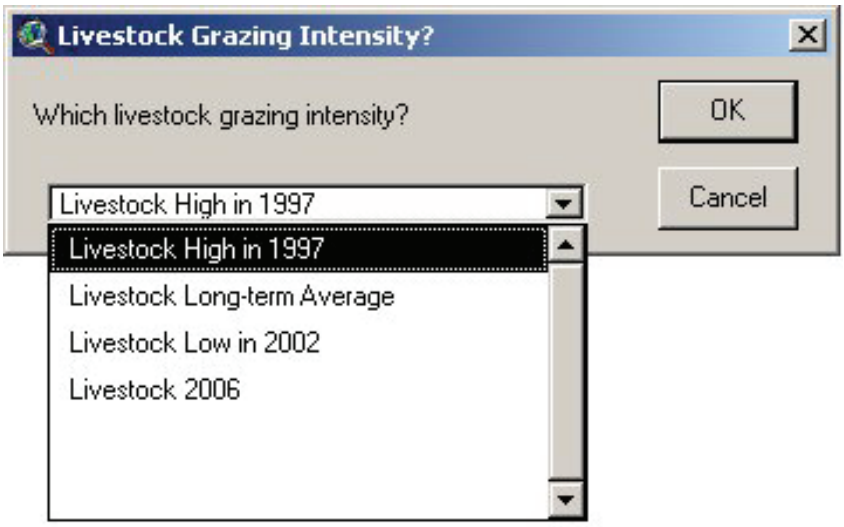


Figure 90. Livestock Grazing Intensity Dialogue Box.

7. The "Elk and Deer Utilization Period,"—the next menu item, below—allows the user to determine how many months per year elk and deer are using the chosen study area. For the whole study area, it appears that "6 months" is the most likely scenario. But, on smaller GMUs here and there, differences may occur.

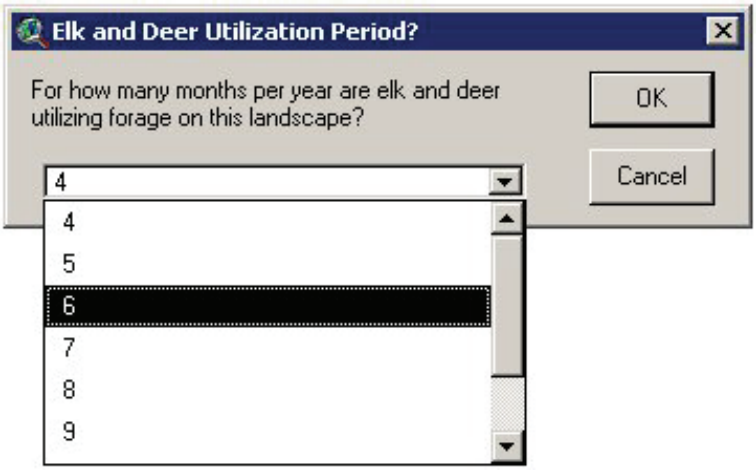


Figure 91. Elk and Deer Utilization Period Dialogue Box.

E. Habitat Model Results for Gunnison, Colorado

Because the Habitat Model in the Gunnison area has been developed to run for multiple DAUs/GMUs, and with several variables, dozens of different results tables can be

generated. In the discussion below we present two of the potential results tables with some associated interpretation.

The Gunnison HPP committee had many conversations about interpreting the model results. Discussions centered around whether to use the winter range or the severe winter range in determining carrying capacity, and about localized DAU/GMU results in comparison to what is observed on the ground. Because the discussions were diverse and did not always reach consensus, it was agreed that the best use of the model in Gunnison was for two purposes:

1. a more generalized consideration of the results, rather than a hard-and-fast use of one modeling scenario as being the determinant of carrying capacity.
2. as an educational tool for considering the role that habitat plays in elk and deer management decisions.

By this standard, the process was very successful and consensus was reached.

The entire Gunnison HPP boundary currently has an estimated 23,300 deer and 14,500 elk, which comes out to approximately 60% deer and 40% elk, and thus the corresponding row in the tables is highlighted in yellow.

Figure 92 below offers results for the whole study area, winter range, mean precipitation, livestock long-term average, and 6 months of wildlife on the winter range.

Mean Precipitation, Winter Range, Whole Study Area, Livestock Long-term Average, 6 Months Wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	53761	102695	151628	100
10	4359	8327	12294	39231	74943	110646	90
20	7331	14004	20677	29324	56016	82708	80
30	9488	18124	26759	22136	42283	62429	70
40	11123	21247	31371	16685	31871	47057	60
50	12406	23699	34991	12406	23699	34991	50
60	13443	25678	37913	8953	17102	25250	40
70	14289	27295	40302	6130	11710	17290	30
80	15003	28659	42315	3751	7165	10579	20
90	15609	29816	44022	1733	3310	4886	10
100	16128	30808	45488	0	0	0	0

Figure 92. Sample Results for the Whole Study Area specified by the table title.

The results in Figure 92, for the winter range, suggest that the current numbers of elk and deer are between the low and middle thresholds. Such a management situation could be construed as being prudent and as protecting the resource from the potential damage that can be caused by overgrazing.

Because of the way that winter range is defined, and because elk/deer seasonal migrations are complex in Gunnison, the committee also wanted to consider the severe winter range as a viable option in considering carrying capacity. Winter range polygons are drawn at a broad scale to include areas where big game may spend portions of the winter depending on annual snow depths. High elevation areas where elk sometimes winter are often unsuitable for mule deer, therefore including plant production in those areas as available to deer was unrealistic. Figure 93, below, offers the same analysis except on severe winter range rather than winter range.

Mean Precipitation, Severe Winter Range, Whole Study Area, Livestock Long-term Average, 6 Months Wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	33663	56702	79742	100
10	2729	4597	6466	24561	41373	58194	90
20	4590	7732	10874	18360	30928	43496	80
30	5941	10007	14073	13860	23346	32832	70
40	6965	11732	16498	10448	17598	24747	60
50	7768	13085	18402	7768	13085	18402	50
60	8417	14178	19939	5606	9443	13279	40
70	8947	15071	21195	3838	6465	9093	30
80	9394	15824	22254	2349	3956	5564	20
90	9773	16462	23152	1085	1827	2570	10
100	10099	17011	23923	0	0	0	0

Figure 93. Results Table based on Severe Winter Range.

The results in Figure 93 suggest that the current numbers of elk and deer are near the high threshold. Such a management situation would be construed as "at, or nearing above, carrying capacity." In addition, it would be important to keep a close eye on elk and deer numbers and their impacts on the range. When elk and deer numbers approach the high threshold, impacts on the range can be construed as being caused by an overabundance of animals, rather than a localized distribution problem.

Using the results table generated in Figure 93, we can create a breakdown of how the forage was allocated across the severe winter range landscape.

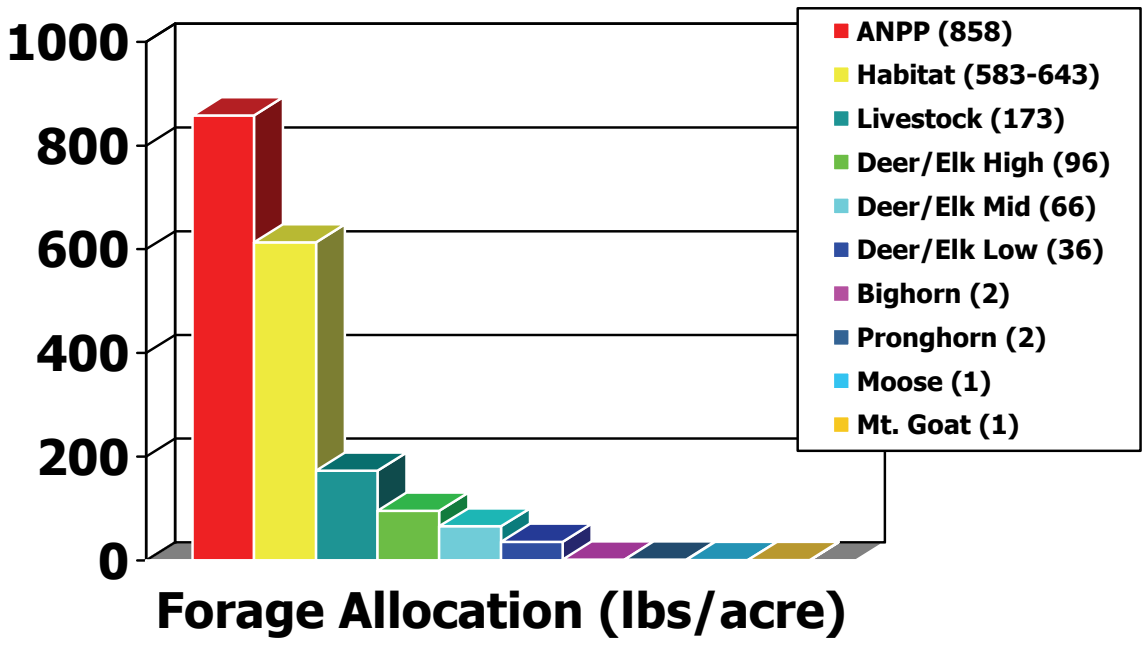


Figure 94. Forage Allocation using the results table in Figure 93.

Figure 94 depicts the amount of forage that is allocated to each forage utilization component in the model. In the severe winter range, the average forage production was

858 pounds per acre. The habitat retained between 583 and 643 pounds to ensure sustainability. Livestock (ten-year average) consumed 173 pounds per acre, and deer and elk offtake varied by the threshold level.

The model also has available menu options to run on the all the DAUs and GMUs in the study area. Each of these model results can be compared to CDOW's objectives and estimates in each unit. Many additional results tables can be generated based on committee needs and interests. With all the variables in the model, very fine scale questions can be answered and management objectives can hopefully be equally attuned.

Appendix 7. Southwest Habitat Assessment Model Case Study (Montelores and Durango)

A. Location

The Southwest study area comprises about 4.54 million acres in the southwest corner of Colorado. The Southwest study area includes two HPP committee boundaries: Montelores and Durango. The area includes the deer DAUs 24, 29, 30, and 52, and the GMUs of 71, 72, 73, 74, 75, 77, 78, 711, 741, 751, and 771.

The study area includes all or parts of nine counties. In addition to significant amounts of privately owned land, the study area contains lands administered by the BLM, USFS, NPS, CDOW, Ute Mountain Tribe, and other state and local agencies.

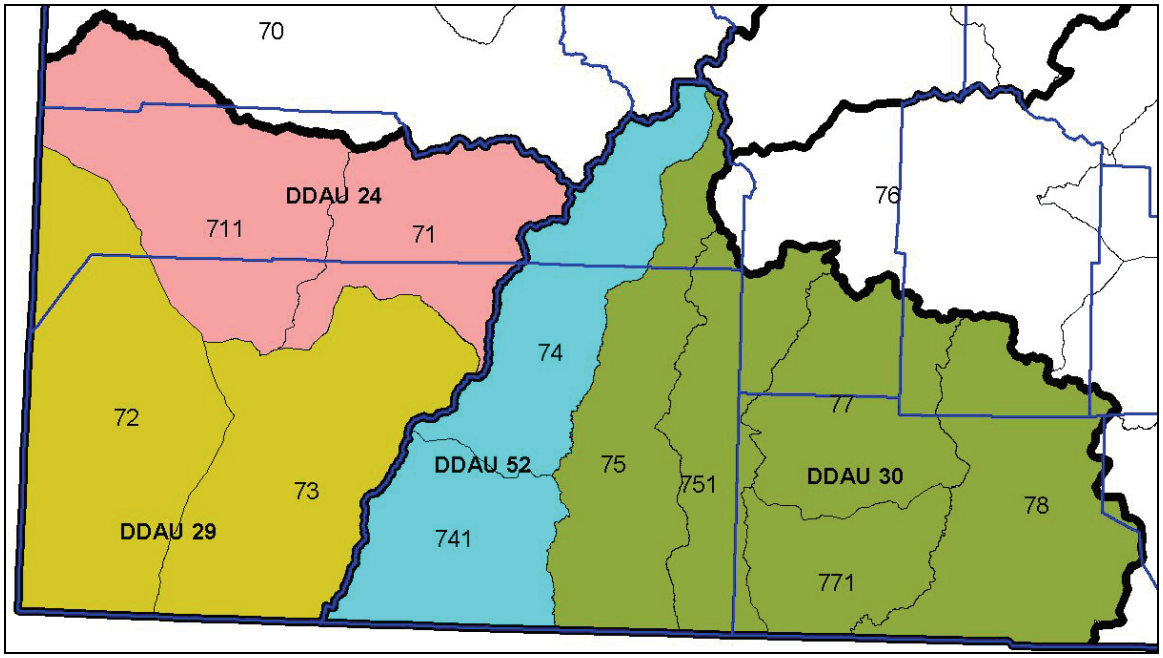


Figure 95. DAUs (bold black numbered, color-shaded), GMUs (black numbered) for the Southwest Study Area. HPP boundaries are in black. County boundaries are blue.

B. Project Partners

Participants involved in the project include the Habitat Model design team and the Montelores and Durango committee members. The design team consists of the following personnel: Gary Wockner- Research Associate and Modeler, Randy Boone - Research Scientist, Pat Tucker – HPP Coordinator. In addition to the design team, all members of the HPP committee were involved in creating the model, a process which took place over several meetings and presentations.

C. Data Sources

The Southwest project was the seventh application of the Habitat Model and the tenth and eleventh committees with which we worked. The management of elk and deer in the area historically has not caused considerable conflicts. The area has a multitude of land management regimens including National Park and Monument, Tribal land, and other public and private owners. The data sources below represent the best fit for the needs of the model.

1. Production Values

Production values for the Southwest study area are composed of USDA-NRCS SSURGO data (described in Section III of this manual), STATSGO data, and 354 points of vegetation data from the BLM at Canyon of the Ancients. The BLM data provided an excellent localized check on the NRCS data. The final vegetation production map is approximately a 25% reduction from the potential suggested in the NRCS data – such a reduction is consistent with many other parts of the state. The image below depicts the production map for the area.

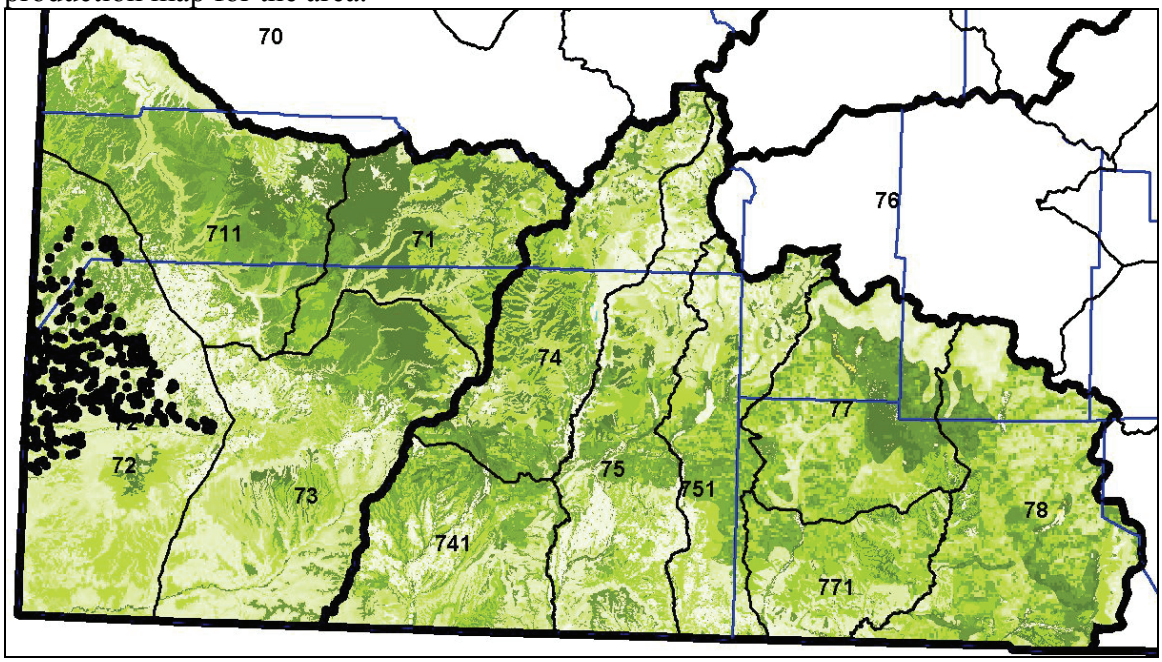


Figure 96. Production map for Southwest HPP area. Darker green color represents higher production values. Black dots are point vegetation data from Canyon of the Ancients National Monument.

2. Winter Range Polygons

The winter range polygons for the Southwest HPP committee area had recently been revised as part of the CDOW WRIS mapping project. Upon discussion with the HPP committee members, it was decided that the WRIS winter range polygons were accurate for the area and no further modification was necessary. Of the approximately 4.54 million acres in the study area, about 2.02 million are elk and deer winter range. The map of winter range is below.

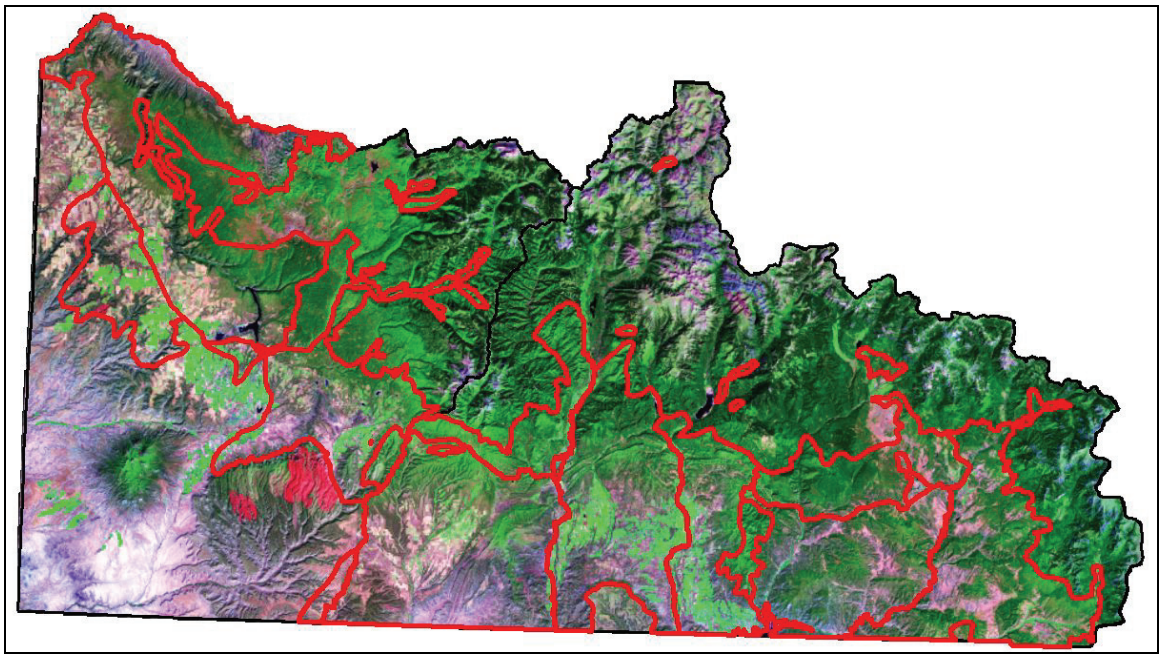


Figure 97. Red outline is elk and deer winter range.

3. Other Wild Ungulate Offtake

Bighorn sheep, moose, and mountain goats also live in the Southwest study area. Populations of species are rather small and stable (compared to elk and deer), and so the committees wished to simply remove the forage that these species consume from the study area prior to estimating elk and deer carrying capacity. The map below depicts the area that these species use. The forage in these areas is reduced to account for this wild ungulate grazing.

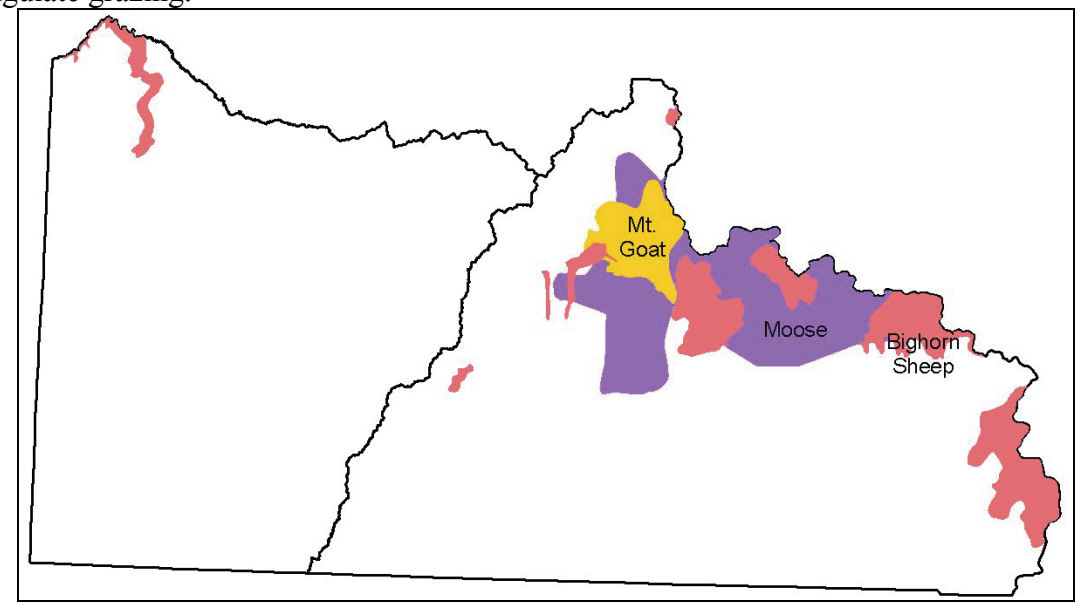


Figure 98. Bighorn sheep, moose, and mountain goat distributions in the Southwest HPP area. Pink = bighorn sheep, tan = mt. goat, purple = moose.

4. Livestock Offtake

The Southwest area has many livestock producers, and thus it was unfeasible to use the procedure used in the North and Middle Park, which was to contact each producer and obtain maps of the areas grazed. It was feasible, however, to get current numbers of livestock from local ranchers. It was also feasible to get livestock numbers (cattle and sheep) from the State of Colorado Agricultural Statistics Service wherein livestock numbers are reported by county for all of Colorado.

Given this county-level data and the estimate from local ranchers, livestock offtake was refined by using satellite imagery which measures the vegetation's greenness across the landscape. These satellite images have been used throughout the world to predict livestock stocking rates by correlating the greenness visible on the landscape with the productivity of the vegetation, and therefore with the number of animals that can be supported. The map below spreads the county-level livestock offtake across the landscape as predicted by forage production and the greenness seen from satellite images through the year. Irrigated row crops are "zeroed" out in the model, so that the results do not offer any forage available to elk and deer in areas that are row-cropped. Fifty percent of the hay that was grown in the area was also removed because it is shipped to New Mexico to feed cattle outside of the study area.

As per the requests of committee members, the Habitat Model can vary livestock offtake by the number of animals grazing. The details of this variation are discussed in Part D.

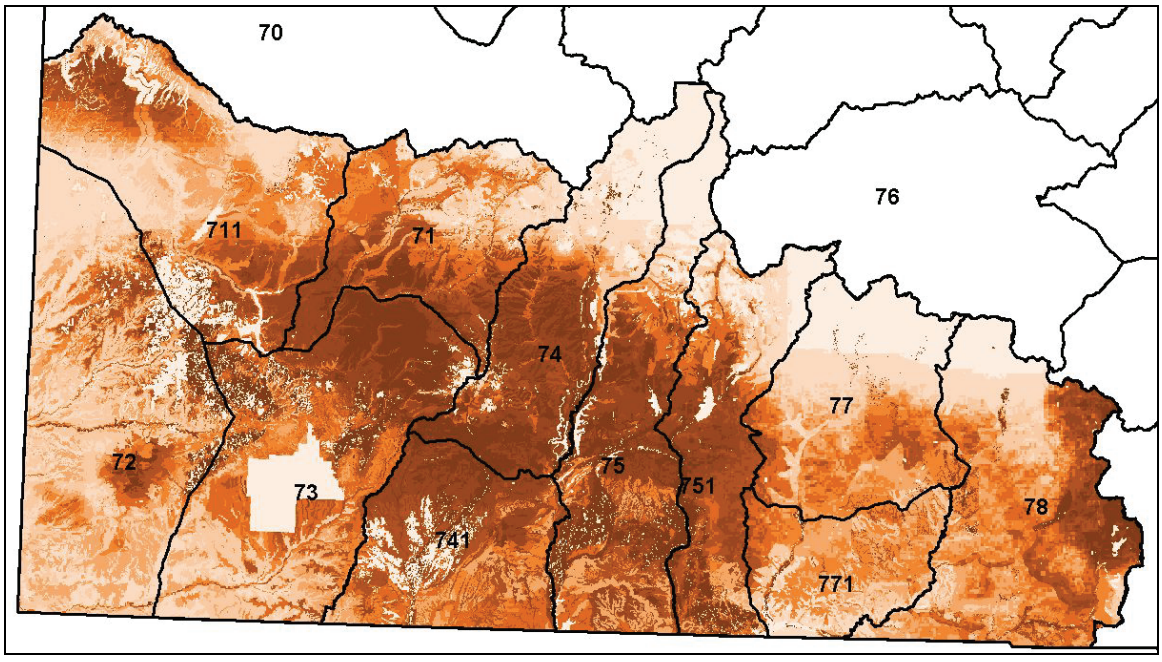


Figure 99. Livestock offtake predicted from satellite images and state statistics. The darker areas represent higher offtake.

D. Model Operation

After the model is installed (see Section VI), the Habitat Assessment Model menu item appears at the top menu bar in ArcView.

1. To start the model, click the Habitat Assessment Model menu item, and select "Run the Model."

2. The opening dialogue box, below, will appear. Click the "OK" button.

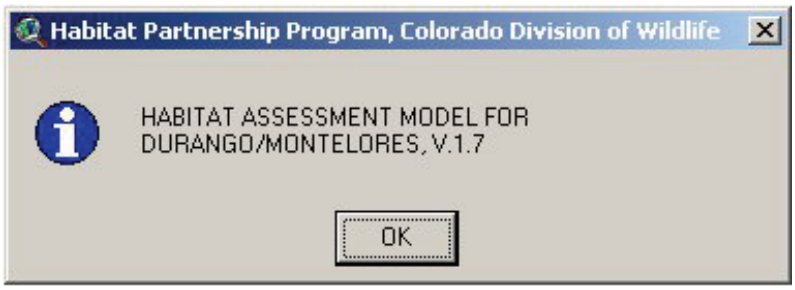


Figure 100. Opening Dialogue Box.

3. The next menu item that appears (below), the "Winter Utilization Areas," allows the user to select one of sixteen winter utilization areas to be modeled. These options include wintering areas within the whole study area, all four DAUs, and all twelve GMUs. This selection determines which winter range area, outlined in Section III, will be used in the modeling scenario.

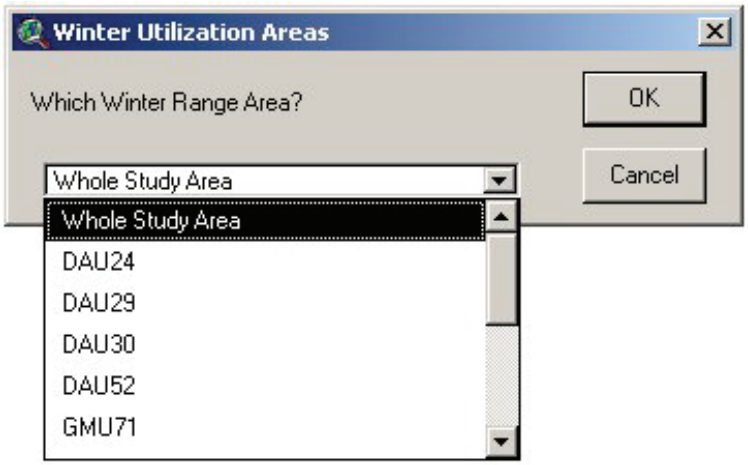


Figure 101. Winter Utilization Areas Dialogue Box.

4. The next menu choice, below, the "Prewinter Precipitation Patterns," provides the user with three precipitation patterns. This choice determines which production values, as described in Section III, will be used for wild ungulate population estimates. Mean, dry, and wet precipitation patterns correspond with average, below average, and above average forage production.

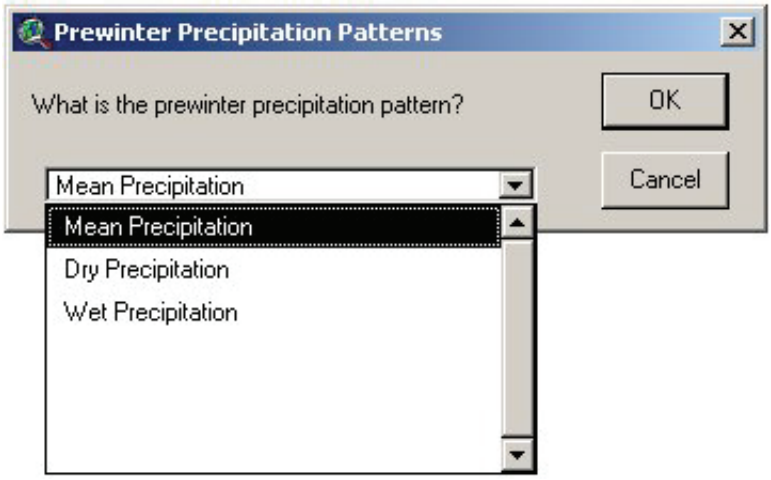


Figure 102. Prewinter Precipitation Dialogue Box.

5. The next choice (Figure 103) is the "Livestock Grazing Intensity." Three choices are available – the "Livestock High in 1997," the "Livestock Ten-Year Average," and the "Livestock Low in 2002." The high in 1997, a very wet year, represents a historically high number of livestock that could be run on the landscape. The "Ten-Year Average" represents a medium number of livestock on the landscape, and the "Livestock Low in 2002" is a historic low.

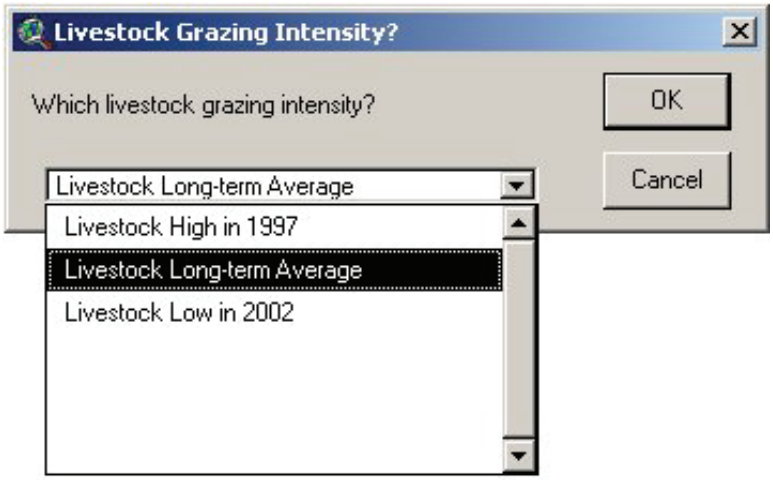


Figure 103. Livestock Grazing Intensity Dialogue Box.

6. The "Elk and Deer Utilization Period,"—the next menu item, below—allows the user to determine how many months per year elk and deer are using the chosen study area. For the whole study area, it appears that "6 months" is the most likely scenario. But, on smaller GMUs here and there, differences may occur.

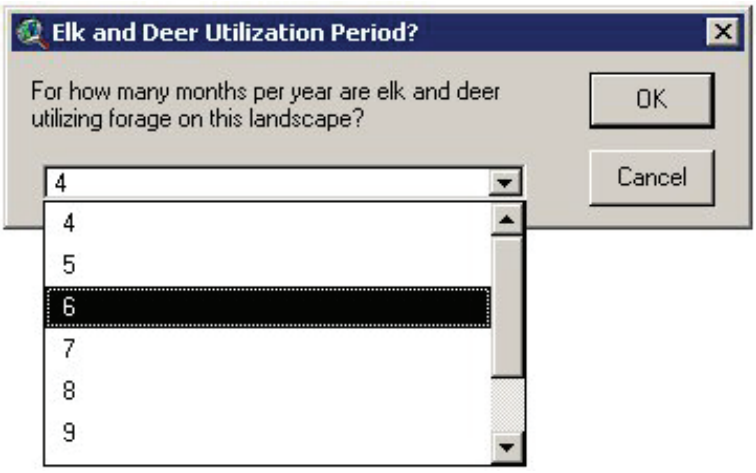


Figure 104. Elk and Deer Utilization Period Dialogue Box.

E. Habitat Model Results for Montelores and Durango HPP Areas

Because the Habitat Model in the Southwest area has been developed to run for multiple DAUs/GMUs, and with several variables, dozens of different results tables can be generated. In the discussion below we present two of the potential results tables with some associated interpretation.

The entire Southwest study area currently has an estimated 33,000 elk and 50,000 deer, which comes out to approximately 40% elk and 60% deer, and thus the corresponding row in the tables is highlighted in yellow.

Figure 105 below offers results for the whole study area, winter range, mean precipitation, livestock long-term average, and 6 months of wildlife on the winter range.

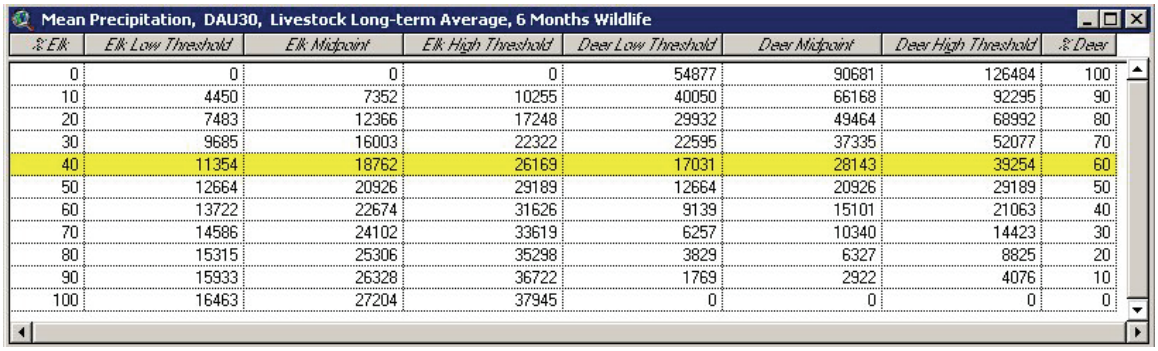
Mean Precipitation, Whole Study Area, Livestock Long-term Average, 6 Months Wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	55500	132638	209776	100
10	4500	10754	17009	40500	96786	153081	90
20	7568	18087	28606	30272	72348	114424	80
30	9795	23408	37021	22852	54611	86370	70
40	11483	27442	43402	17225	41163	65103	60
50	12808	30609	48410	12808	30609	48410	50
60	13877	33165	52453	9242	22088	34934	40
70	14751	35254	55757	6328	15124	23920	30
80	15488	37015	58542	3872	9254	14636	20
90	16113	38509	60905	1789	4274	6760	10
100	16650	39791	62933	0	0	0	0

Figure 105. Sample Results for the Whole Study Area specified by the table title.

The results in Figure 105, for the winter range, suggest that the current numbers of elk and deer are between the middle and high thresholds – just above the middle threshold.

This suggests that range in the Southwest is not being over- or under-grazed, but is roughly in the ballpark of a "carrying capacity" situation.



Mean Precipitation, DAU30, Livestock Long-term Average, 6 Months Wildlife

%Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	%Deer
0	0	0	0	54877	90681	126484	100
10	4450	7352	10255	40050	66168	92295	90
20	7483	12366	17248	29932	49464	68992	80
30	9685	16003	22322	22595	37335	52077	70
40	11354	18762	26169	17031	28143	39254	60
50	12664	20926	29189	12664	20926	29189	50
60	13722	22674	31626	9139	15101	21063	40
70	14586	24102	33619	6257	10340	14423	30
80	15315	25306	35298	3829	6327	8825	20
90	15933	26328	36722	1769	2922	4076	10
100	16463	27204	37945	0	0	0	0

Figure 106. Results Table based Deer DAU 30.

The results in Figure 106 are for Deer DAU 30, which includes GMUs 75, 751, 77, 771, and 78. The current estimated number of animals in DAU 30 is 27,300 deer and 19,500 elk, which again is roughly 60% deer and 40% elk, and thus we analyzed the row of data highlighted in Figure 106. The results in Figure 106 suggest that the current numbers of elk and deer are very near the middle threshold. Again, this suggests that DAU 30 is being grazed at or near carrying capacity.

Given that the model suggests that the Southwest study area is being grazed at or near carrying capacity, we could then suggest that, on an area-wide basis, if there are conflicts occurring between wildlife and livestock, those conflicts are more likely to be caused by the distribution of animals on the range (overlapping ranges, periods of grazing) instead of an overabundance of animals. Likewise, the programs and manipulations employed by HPP to deal with overlapping ranges and periods of grazing are likely a better solution to addressing conflicts than to consider drastic changes in the hunting quotas of elk and deer.

Using the results table generated in Figure 106, we can create a breakdown of how the forage was allocated across the winter range landscape.

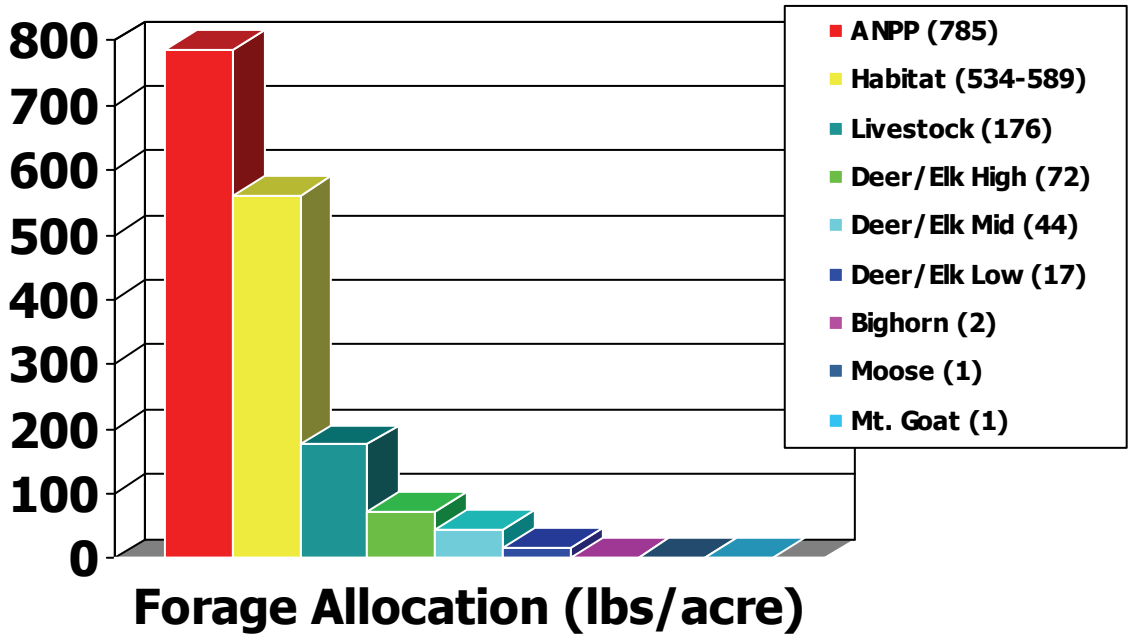


Figure 107. Forage Allocation using the results table in Figure 106.

Figure 107 depicts the amount of forage that is allocated to each forage utilization component in the model. In the winter range, the average forage production was 785 pounds per acre. The habitat retained between 534 and 589 pounds to ensure sustainability. Livestock (ten-year average) consumed 176 pounds per acre, and deer and elk offtake varied by the threshold level.

The model also has available menu options to run on the all the DAUs and GMUs in the study area. Each of these model results can be compared to CDOW's objectives and estimates in each unit. Many additional results tables can be generated based on committee needs and interests. With all the variables in the model, fine scale questions can be answered and management objectives can hopefully be equally attuned.

Appendix 8. Grand Mesa Habitat Assessment Model Case Study

A. Location

The Grand Mesa study area comprises about 950,000 acres in the west-central part of Colorado. The Grand Mesa study area includes one HPP committee boundary: Grand Mesa. The area includes the deer DAU 12, and the GMUs 41, 42, and 421.

The study area includes parts of two counties: Mesa and Garfield. In addition to significant amounts of privately owned land, the study area contains lands administered by the BLM and USFS.

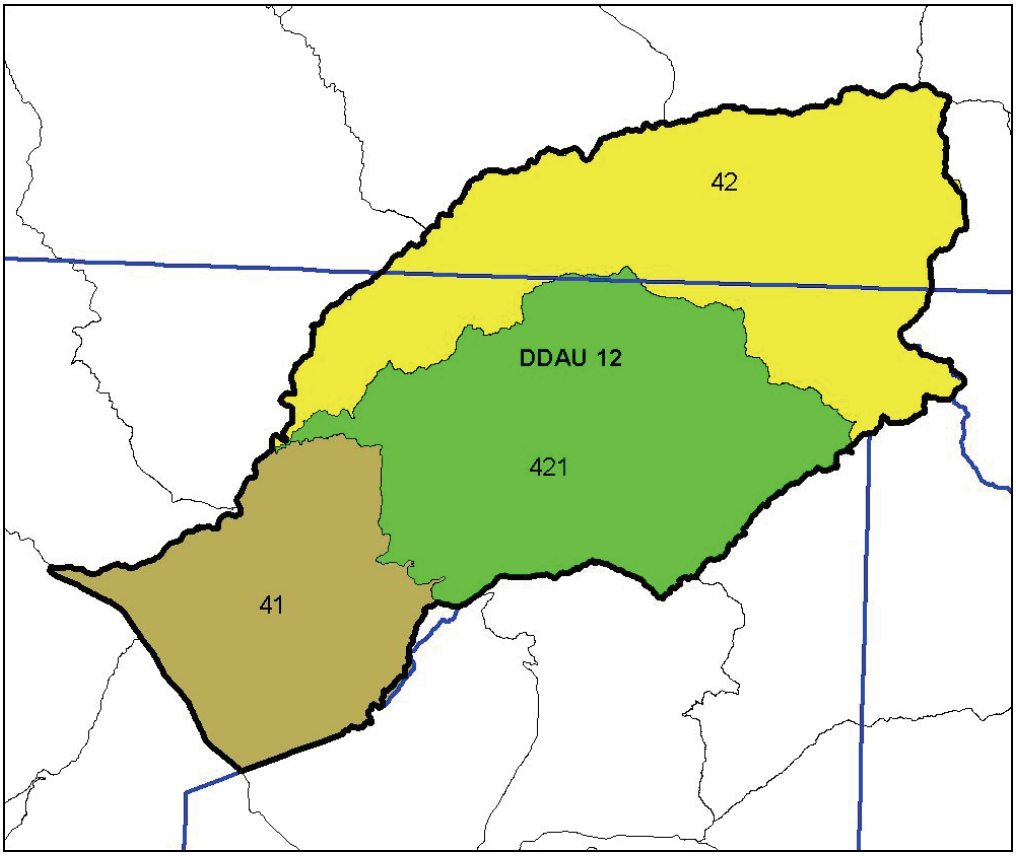


Figure 108. The area is all one deer DAU, 12, and includes three GMUs (black numbered). County boundaries are blue.

B. Project Partners

Participants involved in the project include the Habitat Model design team and the Grand Mesa committee members. The design team consists of the following personnel: Gary Wockner- Research Associate and Modeler, Randy Boone - Research Scientist, Pat

Tucker – HPP Coordinator. In addition to the design team, all members of the HPP committee were involved in creating the model, a process which took place over several meetings and presentations.

C. Data Sources

The Grand Mesa project was the eighth application of the Habitat Model and the twelfth committee with which we worked. The management of elk and deer in the area historically has not caused considerable conflicts. The area has a several land management regimens including public and private owners. The data sources below represent the best fit for the needs of the model.

1. Production Values

Production values for the Grand Mesa study area are composed of USDA-NRCS SSURGO data (described in Section III of this manual) and STATSGO data. STATSGO data were augmented with satellite images of greenness during the growing season, to refine the spatial distribution of forage. The image below depicts the production map for the area.

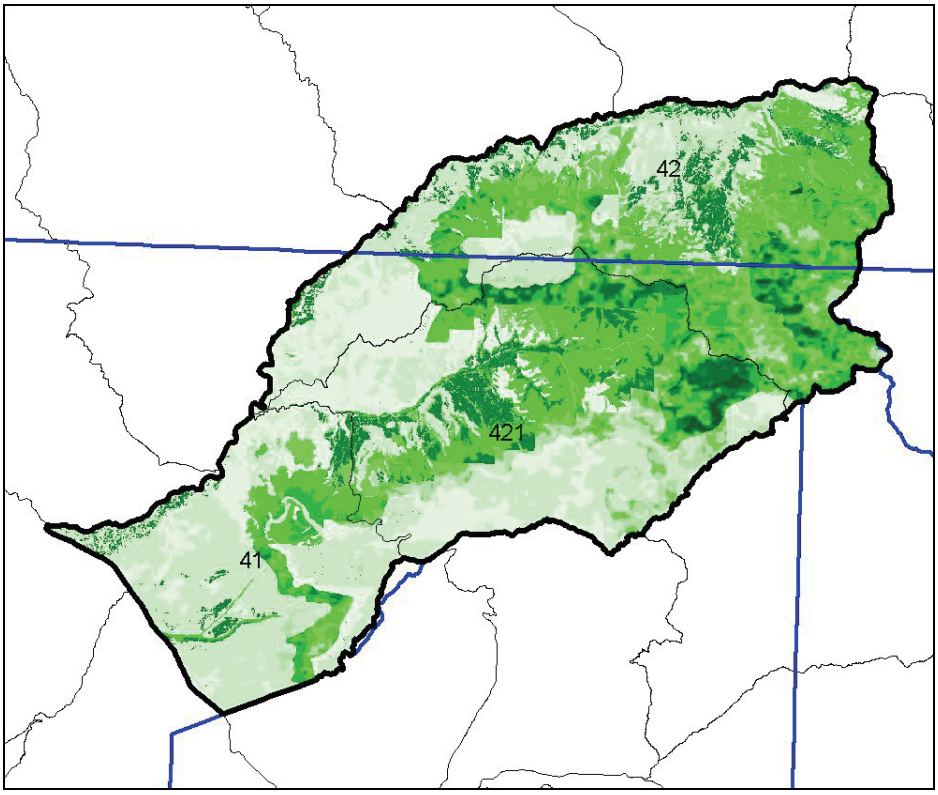


Figure 109. Production map for Grand Mesa HPP area. Darker green color represents higher production values.

2. Winter Range Polygons

The winter range polygons for the Grand Mesa committee area had recently been revised as part of the CDOW WRIS mapping project. Upon discussion with the HPP committee members, it was decided that the WRIS winter range polygons were accurate for the area and no further modification was necessary. Of the approximately 950,000 acres in the study area, about 500,000 acres are elk and deer winter range. The map of winter range is below.

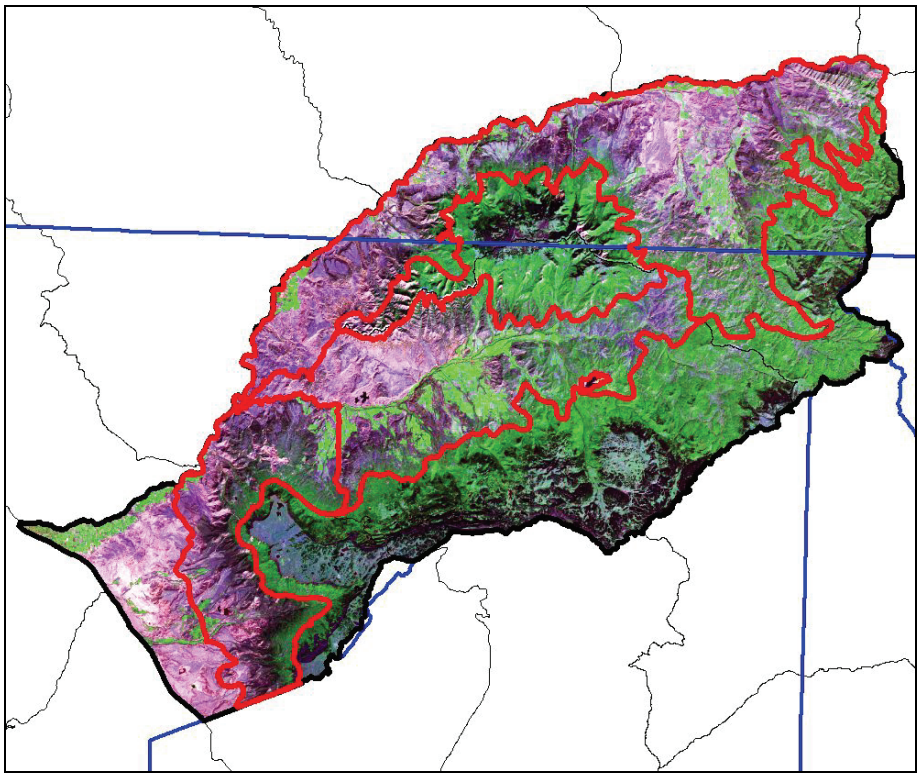


Figure 110. Red outline is elk and deer winter range.

3. Other Wild Ungulate Offtake

In most other areas of the state, there are a number of other wild ungulates grazing on the landscape. In the Grand Mesa area, there is a very small area in the south that is grazed by pronghorn. Because this area is so small, and barely overlaps with elk and deer winter range, it is inconsequential in this analysis.

4. Livestock Offtake

The Grand Mesa area has many livestock producers, and thus it was unfeasible to use the procedure used in the North and Middle Park, which was to contact each producer and obtain maps of the areas grazed. It was feasible, however, to get livestock numbers (cattle and sheep) from the State of Colorado Agricultural Statistics Service wherein livestock numbers are reported by county for all of Colorado.

Given this county-level data and the estimate from local ranchers, livestock offtake was refined by using satellite imagery which measures the vegetation's greenness across the

landscape. These satellite images have been used throughout the world to predict livestock stocking rates by correlating the greenness visible on the landscape with the productivity of the vegetation, and therefore with the number of animals that can be supported. The map below spreads the county-level livestock offtake across the landscape as predicted by forage production and the greenness seen from satellite images through the year.

As per the requests of committee members, the Habitat Model can vary livestock offtake by the number of animals grazing. The details of this variation are discussed in Part D.

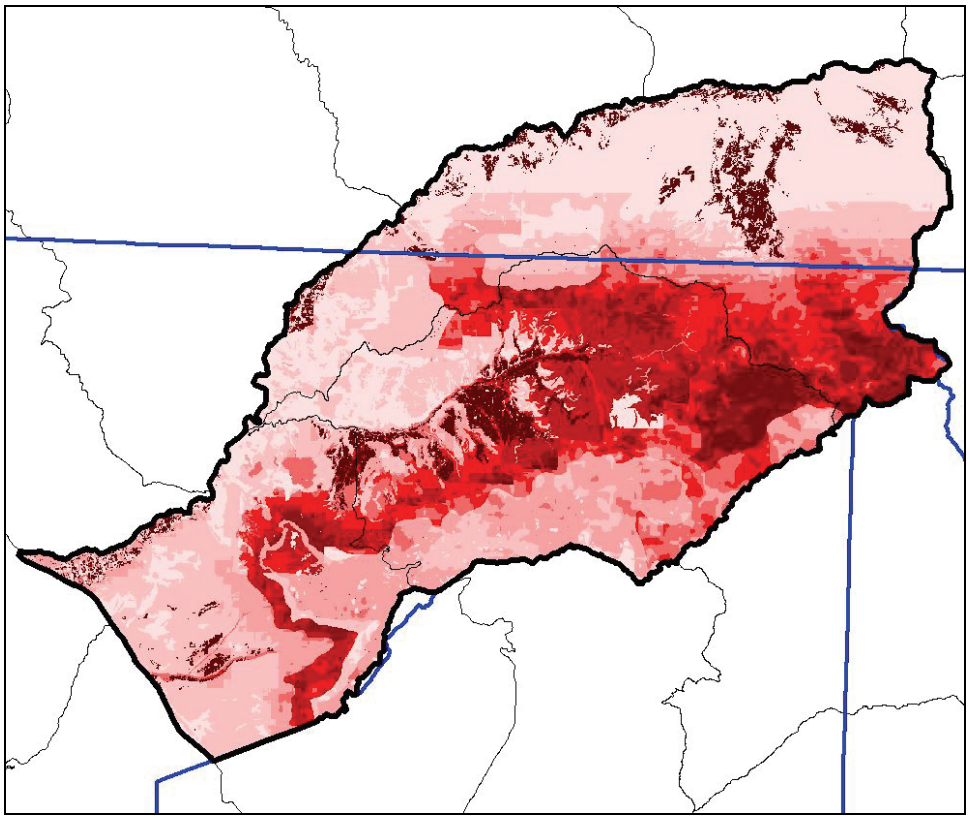


Figure 111. Livestock offtake predicted from satellite images and state statistics. The darker areas represent higher offtake.

D. Model Operation

After the model is installed (see Section VI), the Habitat Assessment Model menu item appears at the top menu bar in ArcView.

1. To start the model, click the Habitat Assessment Model menu item, and select "Run the Model."

2. The opening dialogue box, below, will appear. Click the "OK" button.

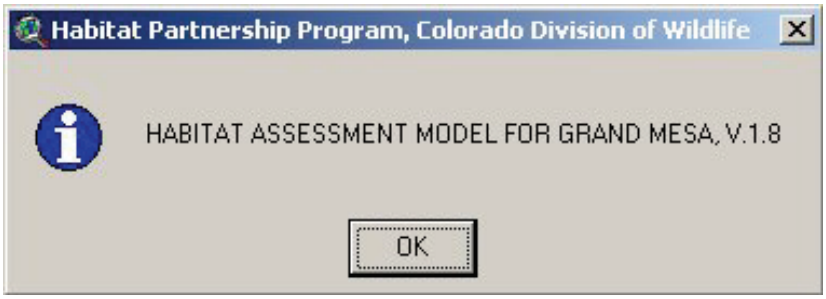


Figure 112. Opening Dialogue Box.

3. The next menu item that appears (below), the "Winter Utilization Areas," allows the user to select one of four winter utilization areas to be modeled. These options include wintering areas within the whole study area (which is DAU 12), and all three GMUs. This selection determines which winter range area, outlined in Section III, will be used in the modeling scenario.

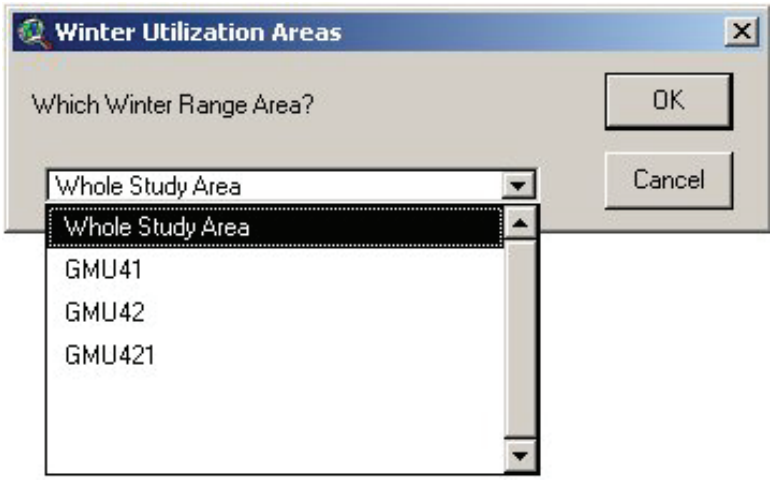


Figure 113. Winter Utilization Areas Dialogue Box.

4. The next menu choice, below, the "Prewinter Precipitation Patterns," provides the user with three precipitation patterns. This choice determines which production values, as described in Section III, will be used for wild ungulate population estimates. Mean, dry, and wet precipitation patterns correspond with average, below average, and above average forage production.

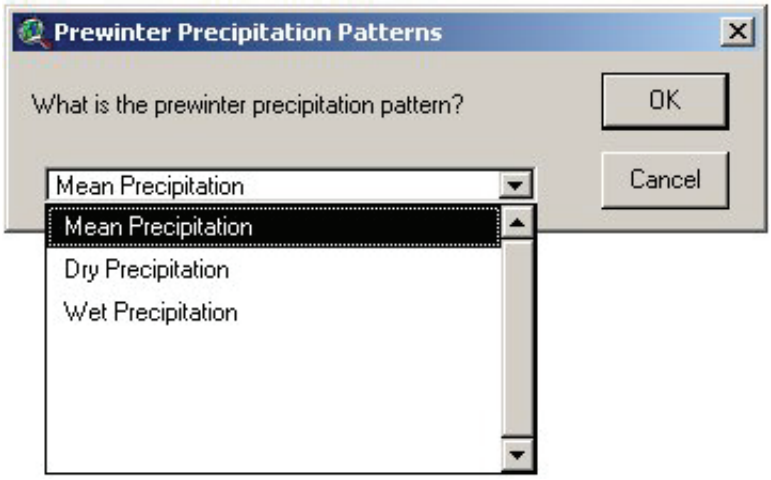


Figure 114. Prewinter Precipitation Dialogue Box.

5. The next choice (Figure 115) is the "Livestock Grazing Intensity." Three choices are available – the "Livestock High in 1997," the "Livestock Ten-Year Average," and the "Livestock Low in 2002." The high in 1997, a very wet year, represents a historically high number of livestock that could be run on the landscape. The "Ten-Year Average" represents a medium number of livestock on the landscape, and the "Livestock Low in 2002" is a historic low, at the peak of a multi-year drought.

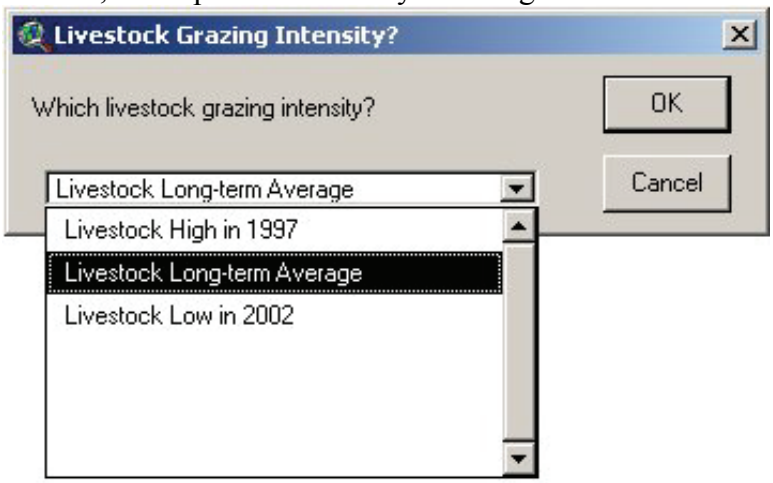


Figure 115. Livestock Grazing Intensity Dialogue Box.

6. The "Elk and Deer Utilization Period,"—the next menu item, below—allows the user to determine how many months per year elk and deer are using the chosen study area. For the whole study area, it appears that "6 months" is the most likely scenario. But, on smaller GMUs here and there, differences may occur.

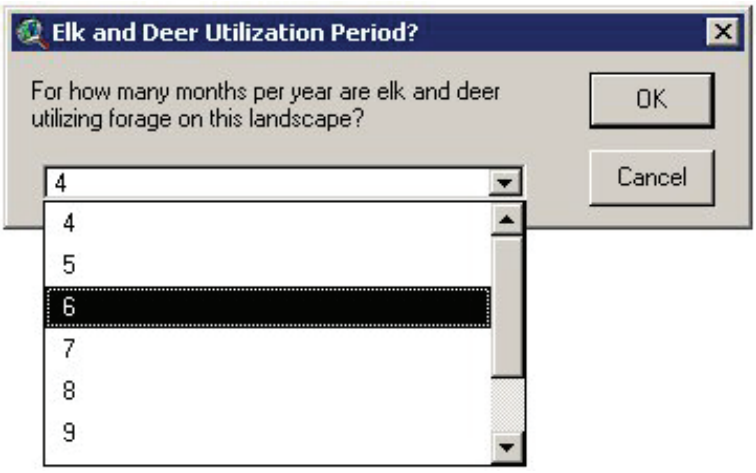


Figure 116. Elk and Deer Utilization Period Dialogue Box.

E. Habitat Model Results for the Grand Mesa HPP Area

Because the Habitat Model in the Grand Mesa has been developed to run for multiple DAUs/GMUs, and with several variables, many different results tables can be generated. In the discussion below we present two of the potential results tables with some associated interpretation.

The entire Grand Mesa study area currently has an estimated 11,500 elk and 33,000 deer, which comes out to approximately 25% elk and 75% deer, and thus the corresponding rows in the tables is highlighted in yellow. (25/75 falls in between 20-30/70-80)

Figure 117 below offers results for the whole study area, winter range, mean precipitation, livestock long-term average, and 6 months of wildlife on the winter range.

Mean Precipitation, Whole Study Area, Livestock Long-term Average, 6 Months Wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	17691	59630	101569	100
10	1434	4835	8235	12906	43515	74115	90
20	2412	8131	13850	9648	32524	55400	80
30	3122	10524	17925	7284	24552	41819	70
40	3660	12337	21014	5490	18506	31521	60
50	4083	13761	23439	4083	13761	23439	50
60	4423	14910	25396	2946	9930	16914	40
70	4702	15849	26996	2017	6799	11581	30
80	4937	16641	28345	1234	4160	7086	20
90	5136	17312	29489	570	1922	3273	10
100	5307	17889	30471	0	0	0	0

Figure 117. Sample Results for the Whole Study Area specified by the table title.

The results in Figure 117, for the winter range, suggest that the current numbers of elk and deer are between the middle and high thresholds – just above the middle threshold. This suggests that the range in the Grand Mesa area is not being over- or under-grazed, but is roughly in the ballpark of a "carrying capacity" situation.

Mean Precipitation, GMU41, Livestock Long-term Average, 6 Months Wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	7421	13717	20012	100
10	602	1112	1623	5418	10008	14607	90
20	1012	1870	2729	4048	7480	10916	80
30	1310	2421	3532	3056	5648	8240	70
40	1535	2838	4140	2303	4257	6210	60
50	1713	3165	4618	1713	3165	4618	50
60	1856	3430	5004	1236	2284	3333	40
70	1972	3646	5319	846	1564	2282	30
80	2071	3828	5585	518	957	1396	20
90	2155	3982	5810	239	442	645	10
100	2226	4115	6004	0	0	0	0

Figure 118. Results Table based on GMU 41.

The results in Figure 118 are for GMU 41. In addition, results tables can also be generated for the other two GMUs.

Given that the model suggests that the Grand Mesa study area is being grazed at or near carrying capacity, we could then suggest that, on an area-wide basis, if there are conflicts occurring between wildlife and livestock, those conflicts are more likely to be caused by the distribution of animals on the range (overlapping ranges, periods of grazing) instead of an overabundance of animals. Likewise, the programs and manipulations employed by HPP to deal with overlapping ranges and periods of grazing are likely a better solution to addressing conflicts than to consider drastic changes in the hunting quotas of elk and deer.

Using the results table generated in Figure 117, we can create a breakdown of how the forage was allocated across the winter range landscape.

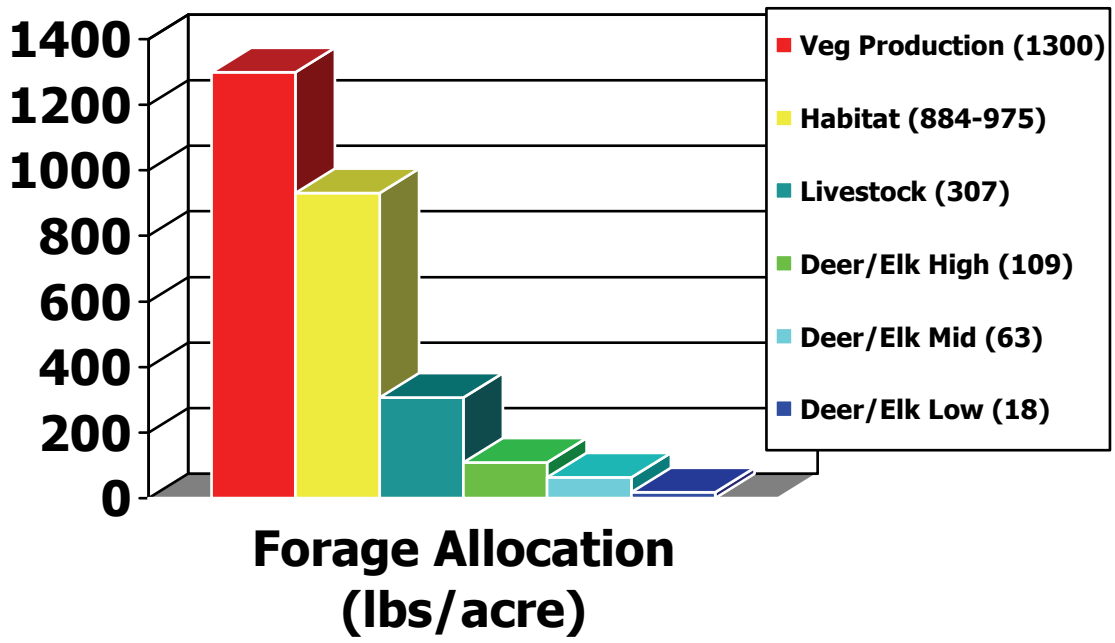


Figure 119. Forage Allocation using the results table in Figure 117.

Figure 119 depicts the amount of forage that is allocated to each forage utilization component in the model. In the winter range, the average forage production was 1300 pounds per acre. The habitat retained between 884 and 975 pounds to ensure sustainability. Livestock (ten-year average) consumed 307 pounds per acre, and deer and elk offtake varied by the threshold level.

The values presented for vegetation production and livestock offtake in Figure 119 are considerably higher than in other HPP committee areas where the model has previously been applied. We speculate that, because the Grand Mesa area is of overall lower elevation, both forage production and livestock offtake are higher than in other parts of the state.

The model also has available menu options to run on the other GMUs in the study area. Each of these model results can be compared to CDOW's objectives and estimates in each unit. Many additional results tables can be generated based on committee needs and interests. With all the variables in the model, fine scale questions can be answered and management objectives can hopefully be equally attuned.

Appendix 9. Uncompahgre Habitat Assessment Model Case Study

A. Location

The Uncompahgre study area comprises about 3.18 million acres in the southwest part of Colorado. The Uncompahgre study area includes one HPP committee boundary: Uncompahgre. The area includes the deer DAUs 19, 23, 24, and 40, and the GMUs 60, 61, 62, 64, 65, and 70.

The study area includes all or parts of eight counties: Mesa, Montrose, Gunnison, Hinsdale, Ouray, San Miguel, Delta, and Dolores. In addition to significant amounts of privately owned land, the study area contains lands administered by the BLM and USFS.

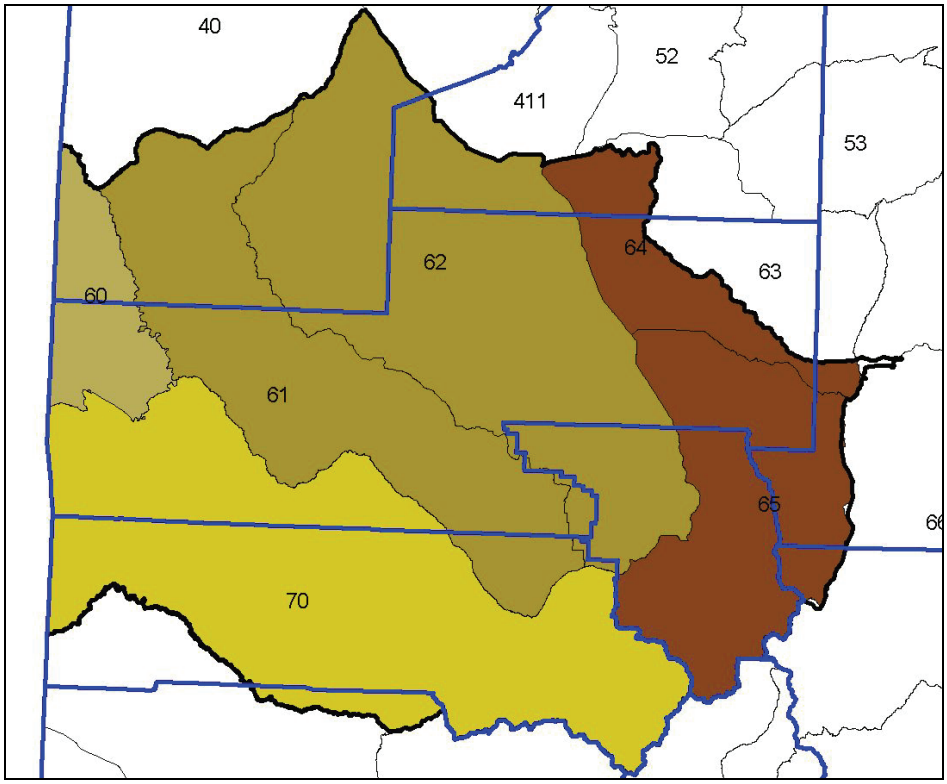


Figure 120. The area comprises four DAUs and six GMUs (numbered black) and all or part of eight counties. County boundaries are blue.

B. Project Partners

Participants involved in the project include the Habitat Model design team and the Uncompahgre committee members. The design team consists of the following personnel: Gary Wockner- Research Associate and Modeler, Randy Boone - Research Scientist, Pat Tucker – HPP Coordinator. In addition to the design team, all members of the HPP

committee were involved in creating the model, a process which took place over several meetings and presentations.

C. Data Sources

The Uncompahgre project was the ninth application of the Habitat Model and the thirteenth committee with which we worked. The management of elk and deer in the area historically has not caused considerable conflicts. The area has several land management regimens including public and private owners. The data sources below represent the best fit for the needs of the model.

1. Production Values

Production values for the Uncompahgre study area are composed of USDA-NRCS SSURGO data (described in Section III of this manual) and STATSGO data. The image below depicts the production map for the area.

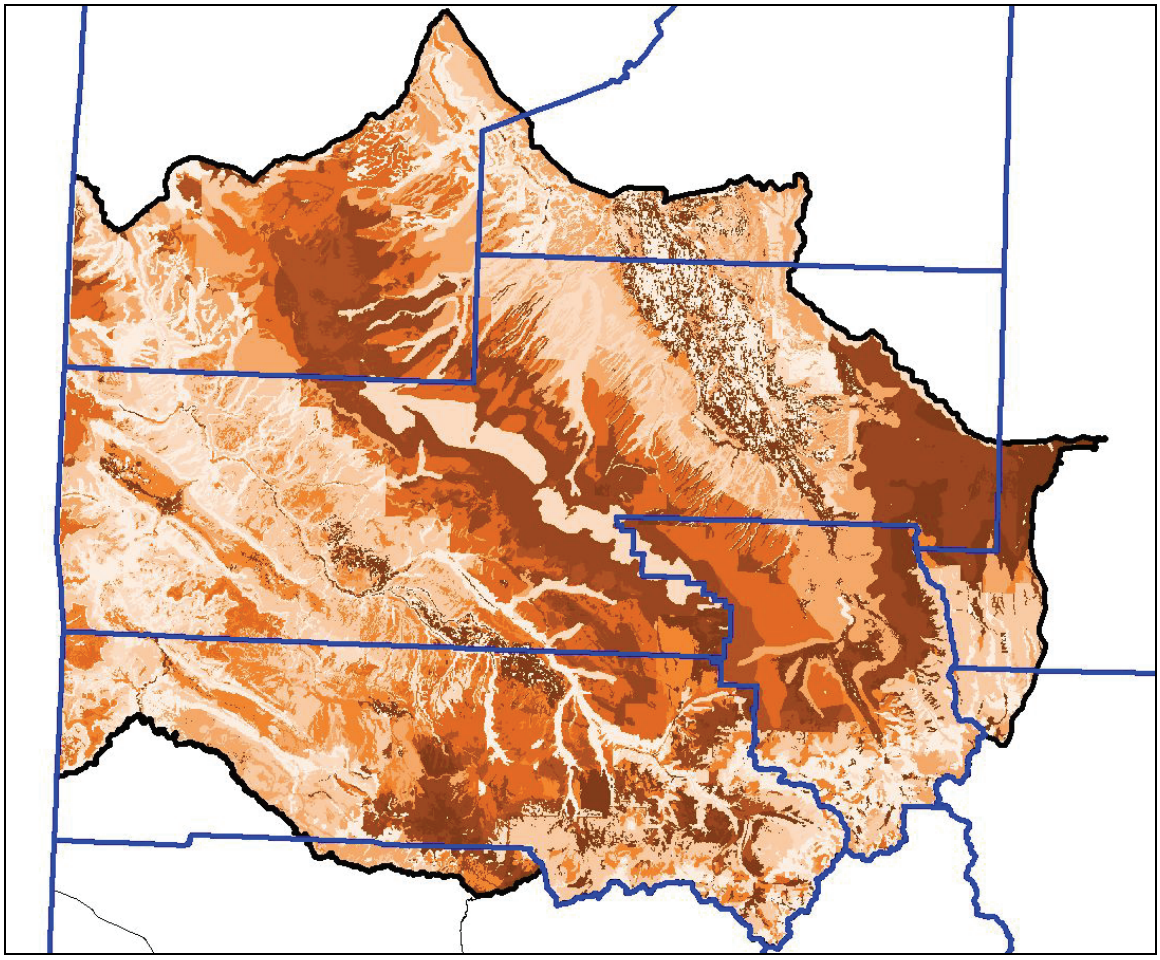


Figure 121. Production map for the Uncompahgre HPP area. Darker color represents higher production values.

2. Winter Range Polygons

The winter range polygons for the Uncompahgre committee area had recently been revised as part of the CDOW WRIS mapping project. Upon discussion with the HPP committee members, it was decided that the WRIS winter range polygons were accurate for the area and no further modification was necessary. Of the approximately 3.18 million acres in the study area, about 2.06 million acres are elk and deer winter range. The map of winter range is below.

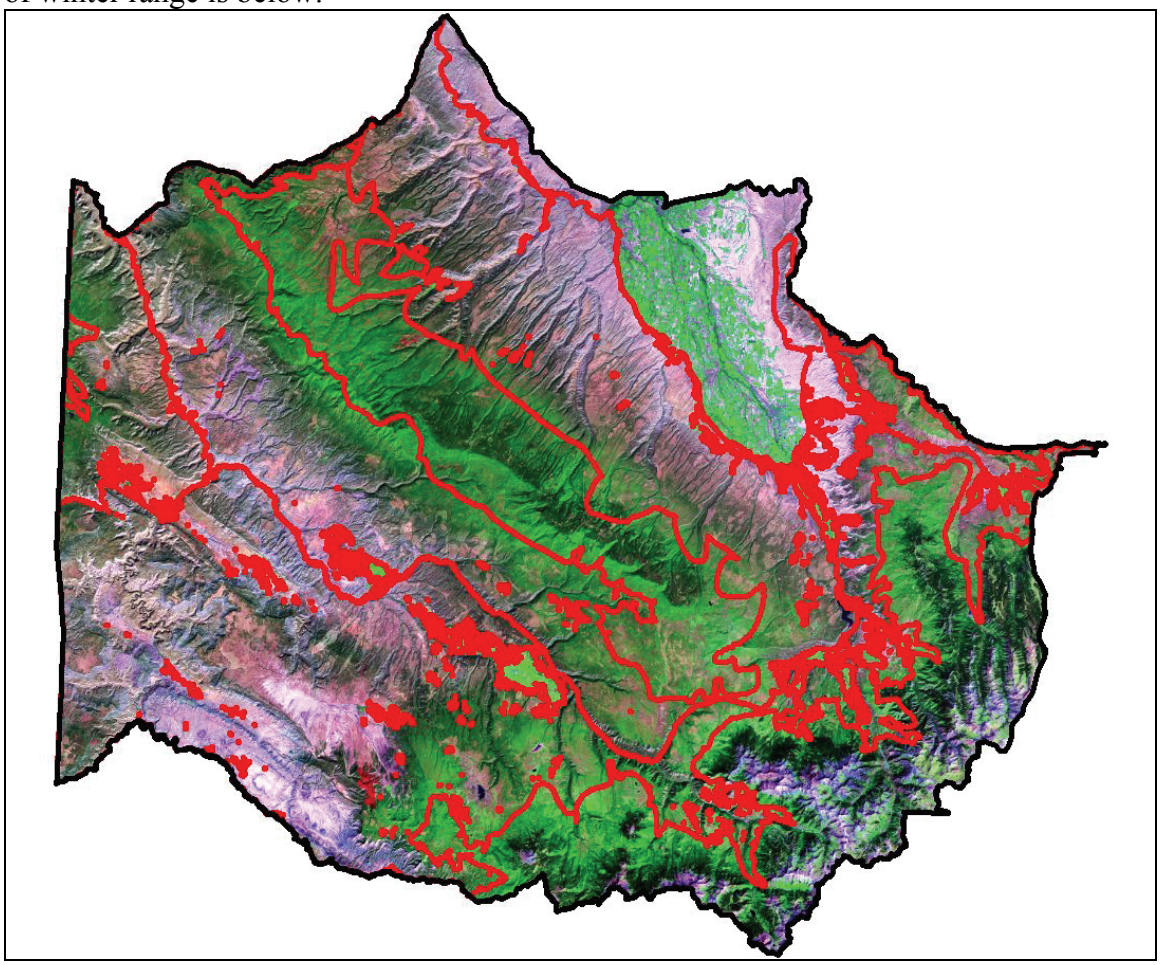


Figure 122. Red outline is elk and deer winter range.

3. Other Wild Ungulate Offtake

The Uncompahgre area of the state also has grazing from wild ungulates including bighorn sheep and pronghorn. The map below depicts the overall range of these two ungulate species. Although their range is somewhat significant, the number of animals and the size of the animals results in very low offtake in pounds per acre.

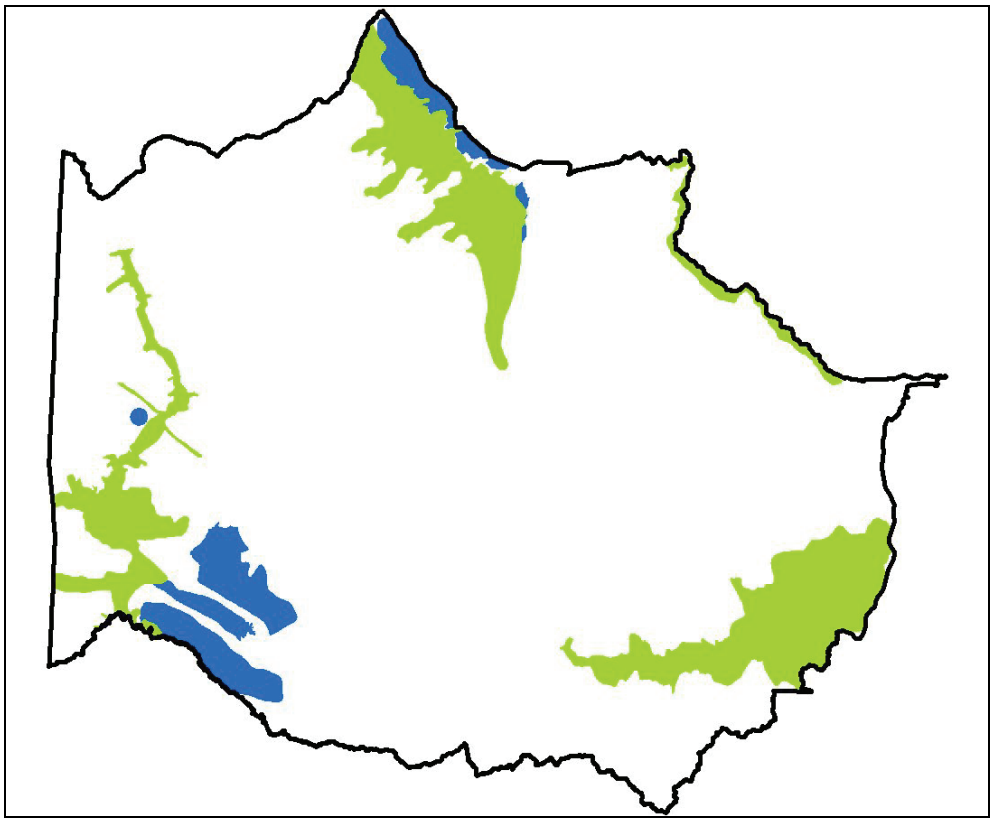


Figure 123. Offtake from bighorn sheep and pronghorn (bighorn = green; pronghorn = blue).

4. Livestock Offtake

The Uncompahgre area has many livestock producers, and thus it was unfeasible to use the procedure used in the North and Middle Park, which was to contact each producer and obtain maps of the areas grazed. It was feasible, however, to get livestock numbers (cattle and sheep) from the State of Colorado Agricultural Statistics Service wherein livestock numbers are reported by county for all of Colorado.

Given this county-level data and the estimate from local ranchers, livestock offtake was refined by using satellite imagery which measures the vegetation's greenness across the landscape. These satellite images have been used throughout the world to predict livestock stocking rates by correlating the greenness visible on the landscape with the productivity of the vegetation, and therefore with the number of animals that can be supported. The map below spreads the county-level livestock offtake across the landscape as predicted by forage production and the greenness seen from satellite images through the year.

As per the requests of committee members, the Habitat Model can vary livestock offtake by the number of animals grazing. The details of this variation are discussed in Part D.

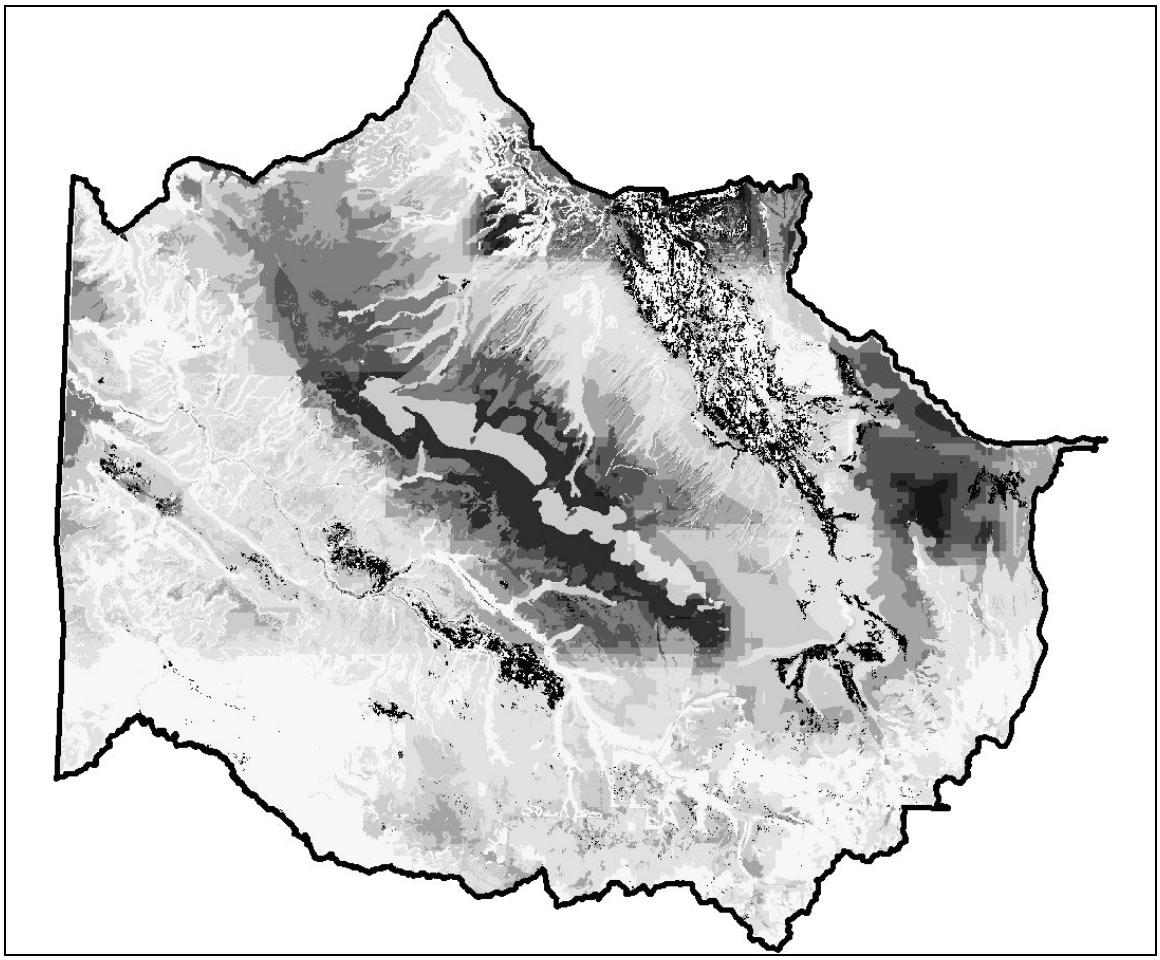


Figure 124. Livestock offtake predicted from satellite images and state statistics. The darker areas represent higher offtake.

D. Model Operation

After the model is installed (see Section VI), the Habitat Assessment Model menu item appears at the top menu bar in ArcView.

1. To start the model, click the Habitat Assessment Model menu item, and select "Run the Model."

2. The opening dialogue box, below, will appear. Click the "OK" button.

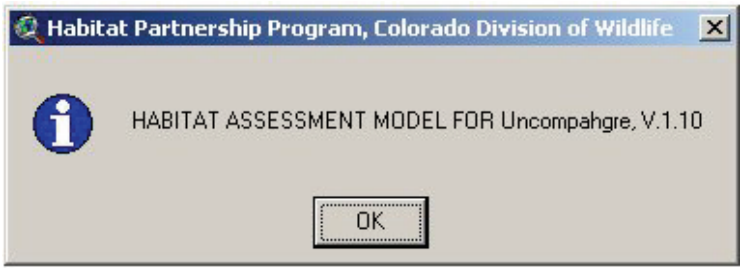


Figure 125. Opening Dialogue Box.

3. The next menu item that appears (below), the "Winter Utilization Areas," allows the user to select one of 11 winter utilization areas to be modeled. These options include wintering areas within the whole study area, any of the four deer DAUs and any of the six GMUs. This selection determines which winter range area, outlined in Section III, will be used in the modeling scenario.

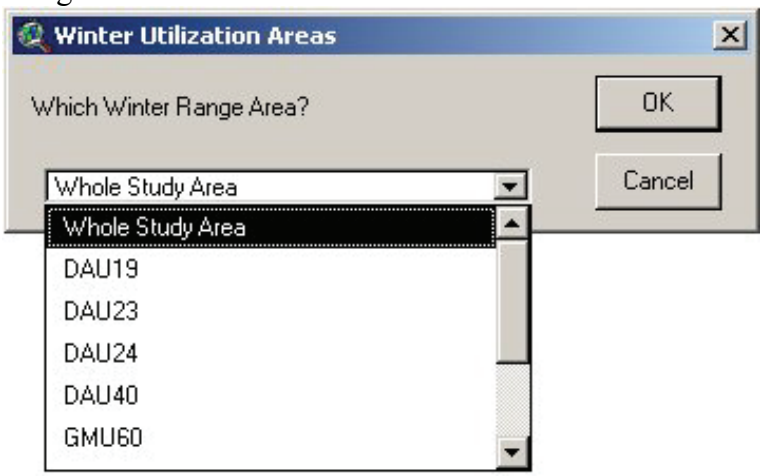


Figure 126. Winter Utilization Areas Dialogue Box.

4. The next menu choice, below, the "Prewinter Precipitation Patterns," provides the user with three precipitation patterns. This choice determines which production values, as described in Section III, will be used for wild ungulate population estimates. Mean, dry, and wet precipitation patterns correspond with average, below average, and above average forage production.

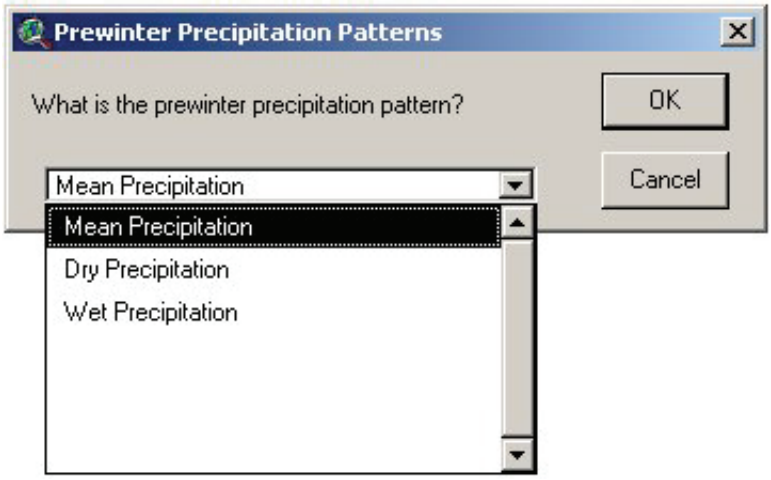


Figure 127. Prewinter Precipitation Dialogue Box.

5. The next choice is the "Livestock Grazing Intensity." Three choices are available – the "Livestock High in 1997," the "Livestock Ten-Year Average," and the "Livestock Low in 2002." The high in 1997, a very wet year, represents a historically high number of livestock that could be run on the landscape. The "Ten-Year Average" represents a medium number of livestock on the landscape, and the "Livestock Low in 2002" is a historic low, at the peak of a multi-year drought.

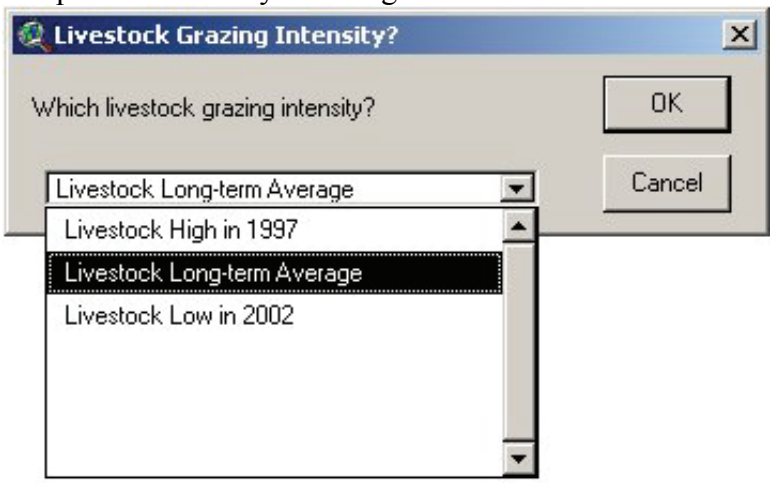


Figure 128. Livestock Grazing Intensity Dialogue Box.

6. The "Elk and Deer Utilization Period,"—the next menu item, below—allows the user to determine how many months per year elk and deer are using the chosen study area. For the whole study area, it appears that "6 months" is the most likely scenario. But, on smaller GMUs here and there, differences may occur.

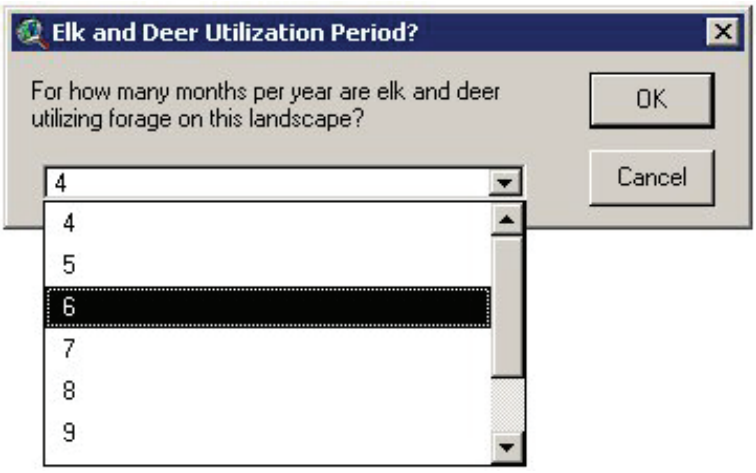


Figure 129. Elk and Deer Utilization Period Dialogue Box.

E. Habitat Model Results for the Uncompahgre HPP Area

Because the Habitat Model in the Uncompahgre has been developed to run for multiple DAUs/GMUs, and with several variables, many different results tables can be generated. In the discussion below we present two of the potential results tables with some associated interpretation.

The entire Uncompahgre study area currently has an estimated 28,400 elk and 59,650 deer, which comes out to approximately 32% elk and 68% deer, and thus the corresponding rows in the tables is highlighted in yellow (32/68 falls in between 30-40/60-70).

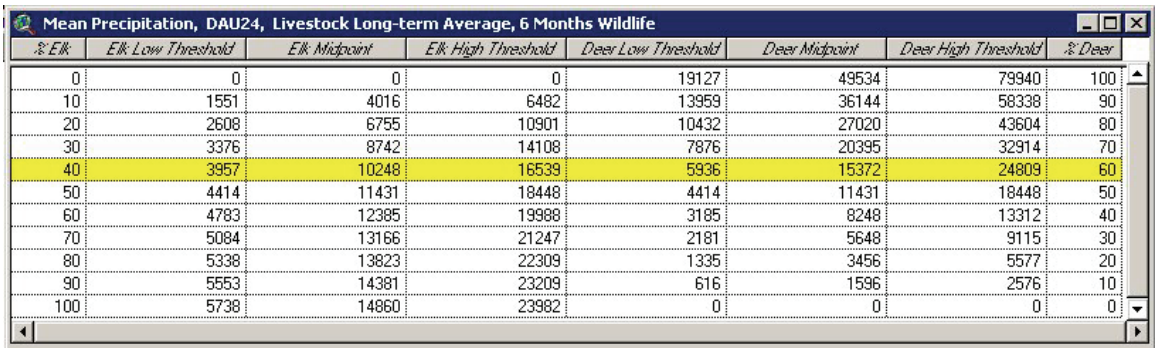
Figure 130 below offers results for the whole study area, winter range, mean precipitation, livestock long-term average, and 6 months of wildlife on the winter range.

Mean Precipitation, Whole Study Area, Livestock Long-term Average, 6 Months Wildlife

%Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	%Deer
0	0	0	0	94017	191487	288958	100
10	7623	15526	23429	68607	139734	210861	90
20	12820	26112	39403	51280	104448	157612	80
30	16592	33794	50996	38709	78841	118974	70
40	19452	39618	59784	29178	59427	89676	60
50	21696	44189	66683	21696	44189	66683	50
60	23508	47880	72251	15656	31888	48119	40
70	24989	50896	76803	10720	21834	32948	30
80	26237	53438	80639	6559	13360	20160	20
90	27296	55595	83894	3030	6171	9312	10
100	28205	57446	86687	0	0	0	0

Figure 130. Sample Results for the Whole Study Area specified by the table title.

The results in Figure 130, for the winter range, suggest that the current numbers of elk and deer are near the middle threshold – just below middle threshold. This suggests that the range in the Uncompahgre area is not being over- or under-grazed, but is roughly in the ballpark of a "carrying capacity" situation.



Mean Precipitation, DAU24, Livestock Long-term Average, 6 Months Wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	19127	49534	79940	100
10	1551	4016	6482	13959	36144	58338	90
20	2608	6755	10901	10432	27020	43604	80
30	3376	8742	14108	7876	20395	32914	70
40	3957	10248	16539	5936	15372	24809	60
50	4414	11431	18448	4414	11431	18448	50
60	4783	12385	19988	3185	8248	13312	40
70	5084	13166	21247	2181	5648	9115	30
80	5338	13823	22309	1335	3456	5577	20
90	5553	14381	23209	616	1596	2576	10
100	5738	14860	23982	0	0	0	0

Figure 131. Results Table based on DAU 24.

The results in Figure 130 are for DAU 24. The on-the-ground estimate for elk and deer in DAU 24 from CDOW is 9,900 elk and 14,850 deer, which is roughly 40% elk and 60% deer. Thus, the estimate predicted by the Habitat Assessment Model suggests that elk and deer in DAU 24 are right at carrying capacity.

Given that the model suggests that the Uncompahgre study area is being grazed at or near carrying capacity, we could then suggest that, on an area-wide basis, if there are conflicts occurring between wildlife and livestock, those conflicts are more likely to be caused by the distribution of animals on the range (overlapping ranges, periods of grazing) instead of an overabundance of animals. Likewise, the programs and manipulations employed by HPP to deal with overlapping ranges and periods of grazing are likely a better solution to addressing conflicts than to consider drastic changes in the hunting quotas of elk and deer.

Using the results table generated in Figure 130, we can create a breakdown of how the forage was allocated across the winter range landscape.

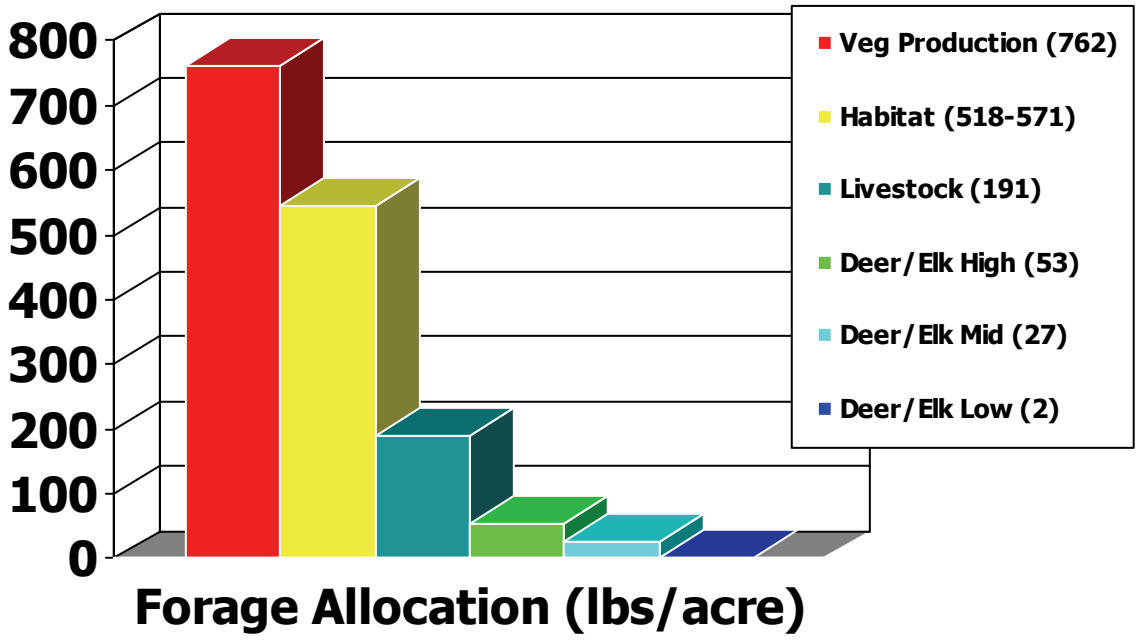


Figure 132. Forage Allocation using the results table in Figure 130.

Figure 132 depicts the amount of forage that is allocated to each forage utilization component in the model. In the winter range, the average forage production was 762 pounds per acre. The habitat retained between 518 and 571 pounds to ensure sustainability. Livestock (ten-year average) consumed 191 pounds per acre, and deer and elk offtake varied by the threshold level.

The model also has available menu options to run on the other DAUs and GMUs in the study area. Each of these model results can be compared to CDOW's objectives and estimates in each unit. Many additional results tables can be generated based on committee needs and interests. With all the variables in the model, fine scale questions can be answered and management objectives can hopefully be equally attuned.

Appendix 10. North Fork Gunnison Habitat Assessment Model Case Study

A. Location

The North Fork Gunnison study area comprises about 1.13 million acres in the south-central part of Colorado. The North Fork Gunnison study area includes one HPP committee boundary: North Fork Gunnison. The area includes the deer DAUs 20, 39, and 51, and the GMUs 411, 52, 521, 53, and 63.

The study area includes all or parts of three counties: Montrose, Gunnison, and Delta. In addition to significant amounts of privately owned land, the study area contains lands administered by the BLM and USFS.

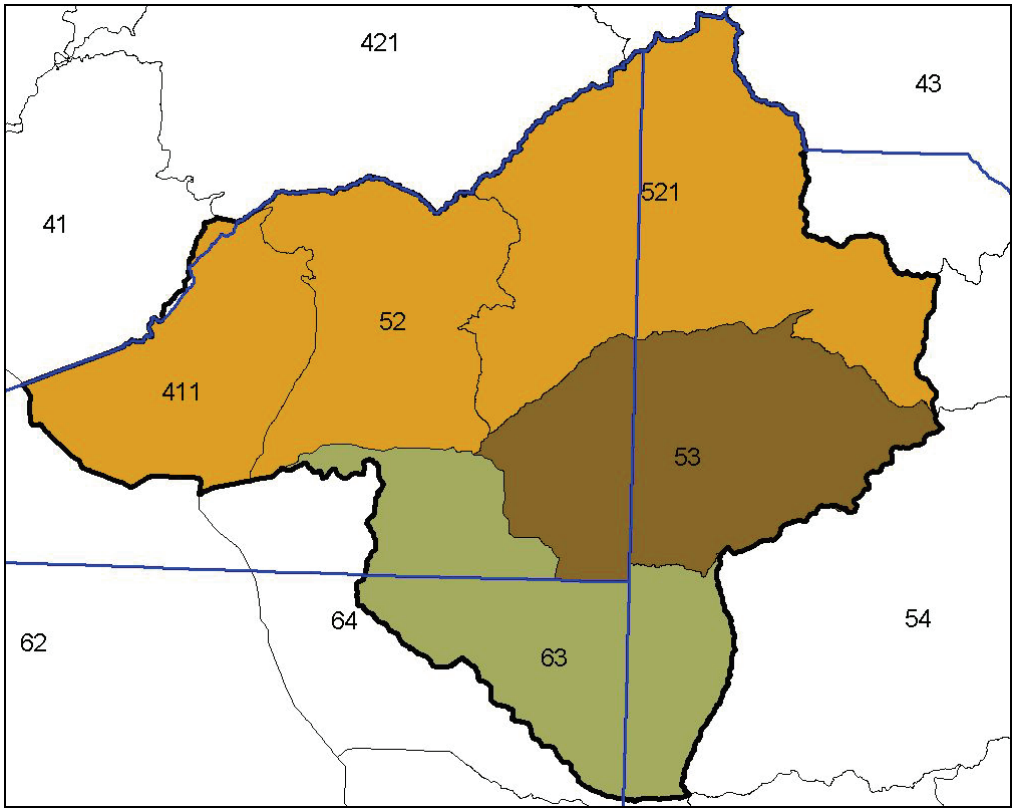


Figure 133. The area comprises three DAUs and five GMUs (numbered black) and parts of three counties. County boundaries are blue.

B. Project Partners

Participants involved in the project include the Habitat Model design team and the North Fork committee members. The design team consists of the following personnel: Gary Wockner- Research Associate and Modeler, Randy Boone - Research Scientist, Pat

Tucker – HPP Coordinator. In addition to the design team, all members of the HPP committee were involved in creating the model, a process which took place over several meetings and presentations.

C. Data Sources

The North Fork project was the tenth application of the Habitat Model and the fourteenth committee with which we worked. The management of elk and deer in the area historically has not caused considerable conflicts. The area has a several land management regimens including public and private owners. The data sources below represent the best fit for the needs of the model.

1. Production Values

Production values for the North Fork study area are composed of USDA-NRCS SSURGO data (described in Section III of this manual) and STATSGO data. The image below depicts the production map for the area.

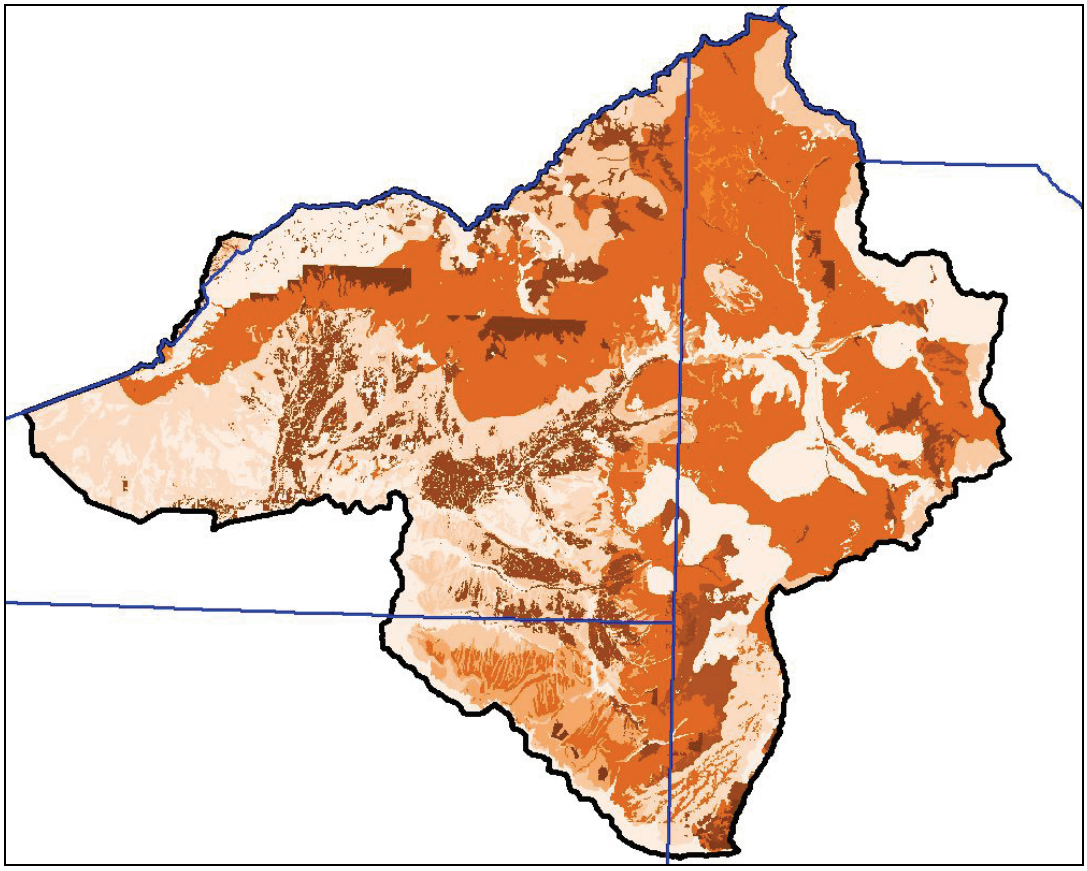


Figure 134. Production map for the North Fork Gunnison HPP area. Darker color represents higher production values.

2. Winter Range Polygons

The winter range polygons for the North Fork committee area had recently been revised as part of the CDOW WRIS mapping project. Upon discussion with the HPP committee members, it was decided that the WRIS winter range polygons were accurate for the area and no further modification was necessary. Of the approximately 1.13 million acres in the study area, about 560,000 acres are elk and deer winter range. The map of winter range is below. Irrigated meadows and row crops are excluded from the winter range calculations.

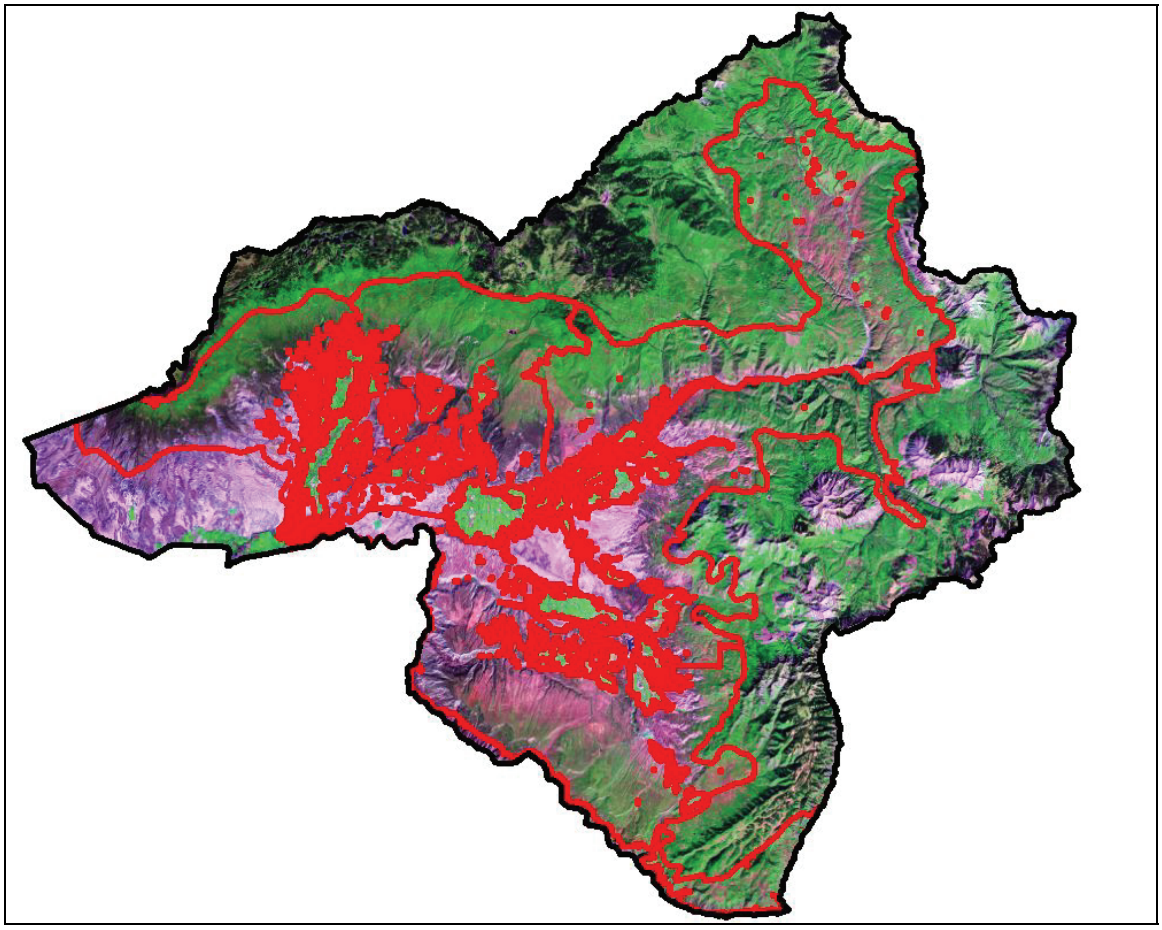


Figure 135. Red outline is elk and deer winter range.

3. Other Wild Ungulate Offtake

The North Fork area of the state also has grazing from wild ungulates including bighorn sheep and pronghorn. The map below depicts the overall range of these two ungulate species. Although their range is somewhat significant, the number of animals and the size of the animals results in very low offtake in pounds per acre.

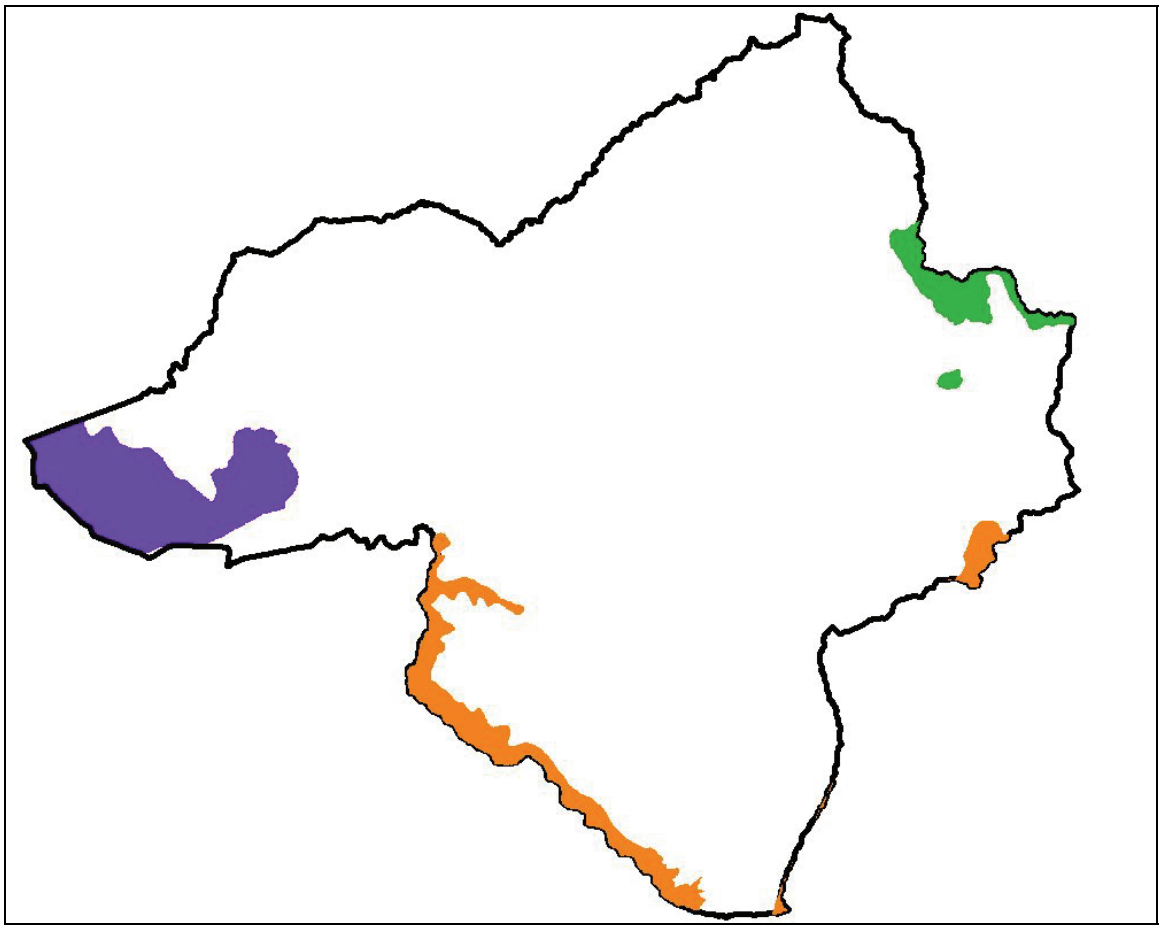


Figure 136. Offtake from bighorn sheep (orange), mountain goats (green), and pronghorn (blue).

4. Livestock Offtake

The North Fork area has many livestock producers, and thus it was unfeasible to use the procedure used in the North and Middle Park, which was to contact each producer and obtain maps of the areas grazed. It was feasible, however, to get livestock numbers (cattle and sheep) from the State of Colorado Agricultural Statistics Service wherein livestock numbers are reported by county for all of Colorado.

Given this county-level data and the estimate from local ranchers, livestock offtake was refined by using satellite imagery which measures the vegetation's greenness across the landscape. These satellite images have been used throughout the world to predict livestock stocking rates by correlating the greenness visible on the landscape with the productivity of the vegetation, and therefore with the number of animals that can be supported. The map below spreads the county-level livestock offtake across the landscape as predicted by forage production and the greenness seen from satellite images through the year.

As per the requests of committee members, the Habitat Model can vary livestock offtake by the number of animals grazing. The details of this variation are discussed in Part D.

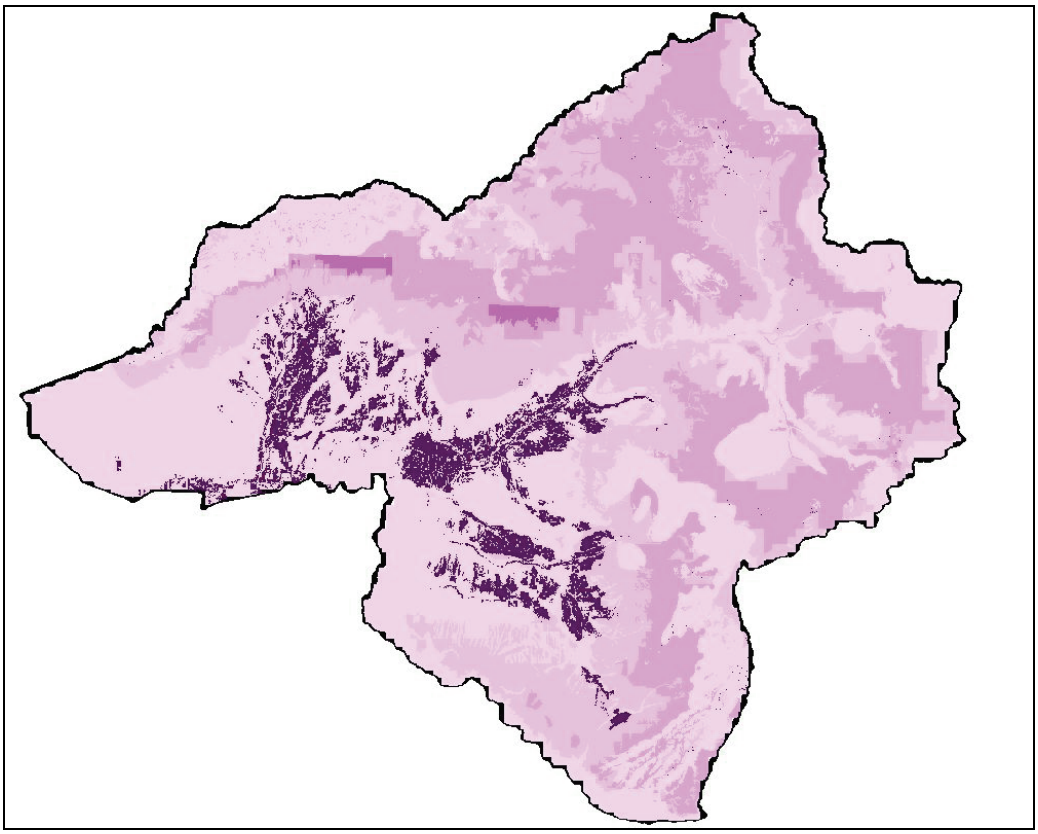


Figure 137. Livestock offtake predicted from satellite images and state statistics. The darker areas represent higher offtake.

D. Model Operation

After the model is installed (see Section VI), the Habitat Assessment Model menu item appears at the top menu bar in ArcView.

1. To start the model, click the Habitat Assessment Model menu item, and select "Run the Model."

2. The opening dialogue box, below, will appear. Click the "OK" button.

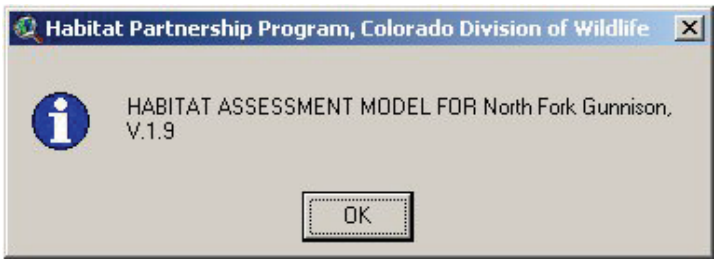


Figure 138. Opening Dialogue Box.

3. The next menu item that appears (below), the "Winter Utilization Areas," allows the user to select one of nine winter utilization areas to be modeled. These options include wintering areas within the whole study area, and any of the three DAUs or five GMUs. This selection determines which winter range area, outlined in Section III, will be used in the modeling scenario.

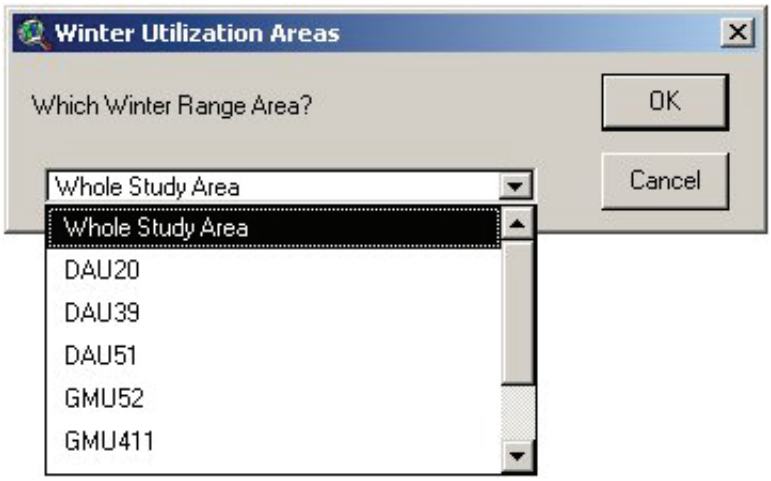


Figure 139. Winter Utilization Areas Dialogue Box.

4. The next menu choice, below, the "Prewinter Precipitation Patterns," provides the user with three precipitation patterns. This choice determines which production values, as described in Section III, will be used for wild ungulate population estimates. Mean, dry, and wet precipitation patterns correspond with average, below average, and above average forage production.

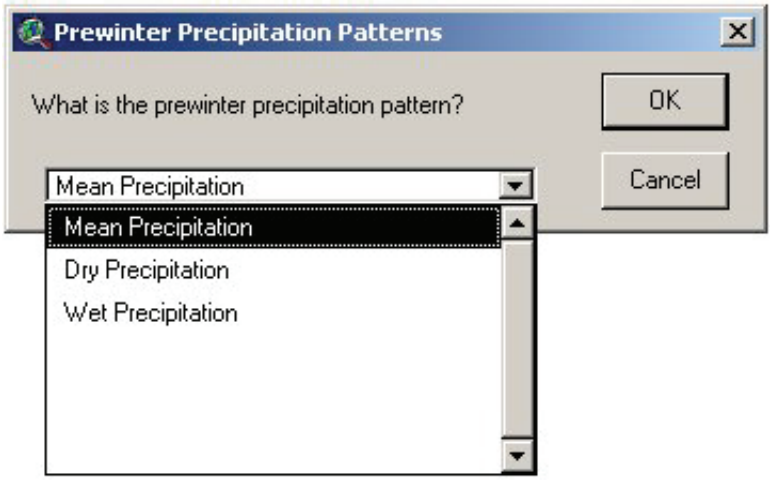


Figure 140. Prewinter Precipitation Dialogue Box.

5. The next choice is the "Livestock Grazing Intensity." Three choices are available – the "Livestock High in 1997," the "Livestock Ten-Year Average," and the "Livestock Low in 2002." The high in 1997, a very wet year, represents a historically high number of livestock that could be run on the landscape. The "Ten-Year Average" represents a medium number of livestock on the landscape, and the "Livestock Low in 2002" is a historic low, at the peak of a recent multi-year drought.

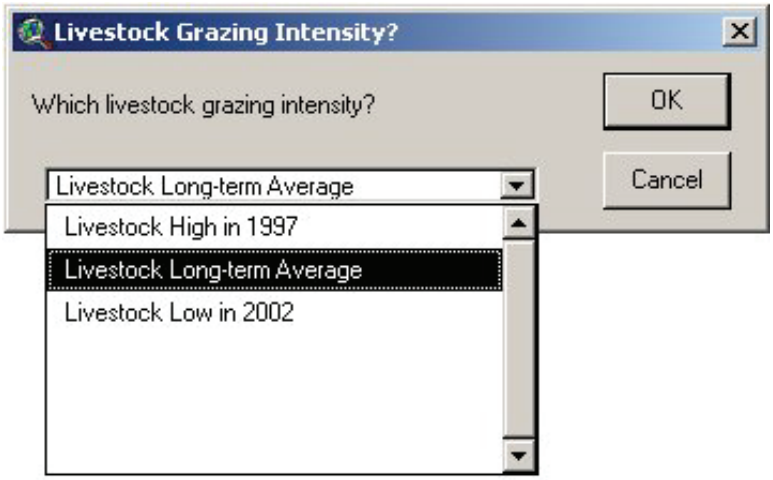


Figure 141. Livestock Grazing Intensity Dialogue Box.

6. The "Elk and Deer Utilization Period,"—the next menu item, below—allows the user to determine how many months per year elk and deer are using the chosen study area. For the whole study area, it appears that "6 months" is the most likely scenario. But, on smaller GMUs here and there, differences may occur.

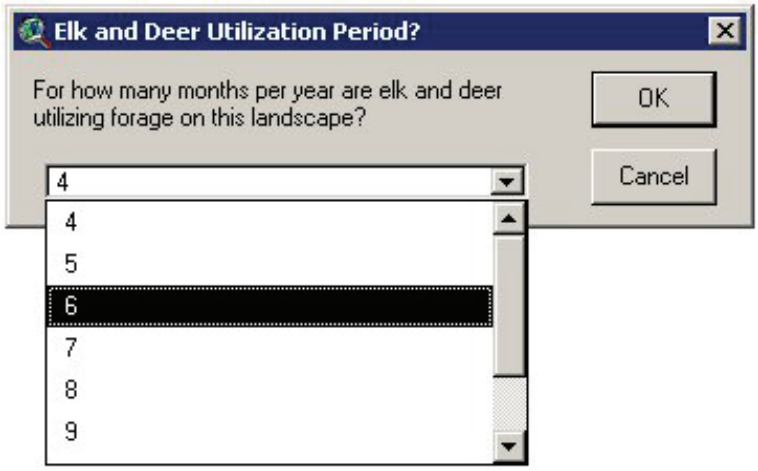


Figure 142. Elk and Deer Utilization Period Dialogue Box.

E. Habitat Model Results for the North Fork HPP Area

Because the Habitat Model in the North Fork area has been developed to run for multiple DAUs/GMUs, and with several variables, many different results tables can be generated. In the discussion below we present two of the potential results tables with some associated interpretation.

The entire North Fork study area currently has an estimated 10,640 elk and 26,900 deer, which comes out to approximately 30% elk and 70% deer, and thus the corresponding row in the tables is highlighted in yellow.

Figure 143 below offers results for the whole study area, winter range, mean precipitation, livestock long-term average, and 6 months of wildlife on the winter range.

Mean Precipitation, Whole Study Area, Livestock Long-term Average, 6 Months Wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	31721	69677	107633	100
10	2572	5649	8727	23148	50841	78543	90
20	4326	9501	14677	17304	38004	58708	80
30	5598	12297	18995	13060	28689	44315	70
40	6563	14416	22269	9845	21624	33404	60
50	7320	16079	24838	7320	16079	24838	50
60	7932	17422	26913	5283	11603	17924	40
70	8431	18520	28608	3617	7945	12273	30
80	8852	19445	30037	2213	4861	7509	20
90	9210	20229	31249	1022	2245	3469	10
100	9516	20903	32290	0	0	0	0

Figure 143. Sample Results for the Whole Study Area specified by the table title.

The results in Figure 143, for the winter range, suggest that the current numbers of elk and deer are slightly below the middle threshold. This suggests that the range in the North Fork area is not being over- or under-grazed, but is roughly in the ballpark of a "carrying capacity" situation.

Mean Precipitation, DAU20, Livestock Long-term Average, 6 Months Wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	4453	10420	16387	100
10	361	845	1329	3249	7605	11961	90
20	607	1421	2235	2428	5684	8940	80
30	786	1839	2892	1834	4290	6747	70
40	921	2156	3390	1382	3234	5085	60
50	1028	2405	3782	1028	2405	3782	50
60	1113	2605	4098	741	1735	2729	40
70	1184	2770	4356	508	1188	1869	30
80	1243	2908	4573	311	727	1143	20
90	1293	3025	4758	144	336	528	10
100	1336	3126	4916	0	0	0	0

Figure 144. Results Table based DAU 20.

The results in Figure 144 are for DAU 20. The on-the-ground estimate for elk and deer in DAU 20 from CDOW is 1,900 elk and 6,600 deer, which is roughly 20% elk and 80% deer. Thus, the estimate predicted by the Habitat Assessment Model suggests that elk and deer in DAU 24 are slightly above carrying capacity.

Given that the model suggests that the North Fork study area is being grazed at or near carrying capacity, we could then suggest that, on an area-wide basis, if there are conflicts occurring between wildlife and livestock, those conflicts are more likely to be caused by the distribution of animals on the range (overlapping ranges, periods of grazing) instead of an overabundance of animals. Likewise, the programs and manipulations employed by HPP to deal with overlapping ranges and periods of grazing are likely a better solution to addressing conflicts than to consider drastic changes in the hunting quotas of elk and deer.

Using the results table generated in Figure 143, we can create a breakdown of how the forage was allocated across the winter range landscape.

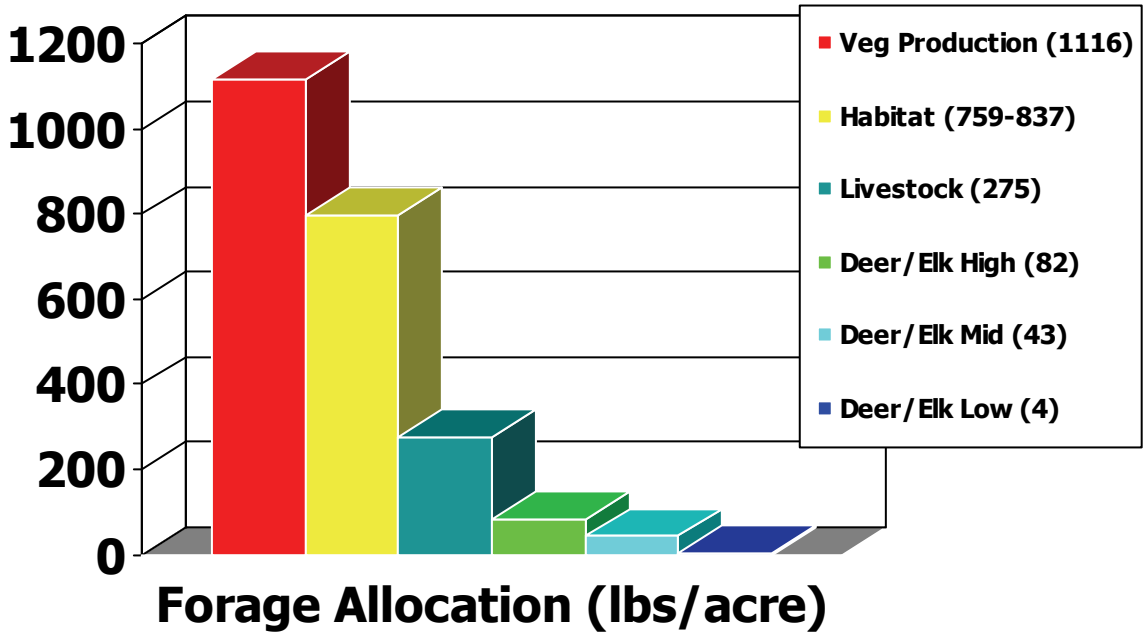


Figure 145. Forage Allocation using the results table in Figure 143.

Figure 145 depicts the amount of forage that is allocated to each forage utilization component in the model. In the winter range, the average forage production was 1116 pounds per acre. The habitat retained between 759 and 837 pounds to ensure sustainability. Livestock (ten-year average) consumed 275 pounds per acre, and deer and elk offtake varied by the threshold level.

The model also has available menu options to run on the other DAUs and GMUs in the study area. Each of these model results can be compared to CDOW's objectives and estimates in each unit. Many additional results tables can be generated based on committee needs and interests. With all the variables in the model, fine scale questions can be answered and management objectives can hopefully be equally attuned.

Appendix 11. Northern Larimer County Habitat Assessment Model Case Study

A. Location

The Northern Larimer County study area comprises about 1.15 million acres in the northern part of Colorado. The Northern Larimer County study area includes one HPP committee boundary: Northern Larimer County. The area includes the deer DAU 4, and the GMUs 7, 8, 9, 19, and 191.

The study area includes the northern half of Larimer County. In addition to significant amounts of privately owned land, the study area contains lands administered by the BLM, USFS and State Wildlife Areas.

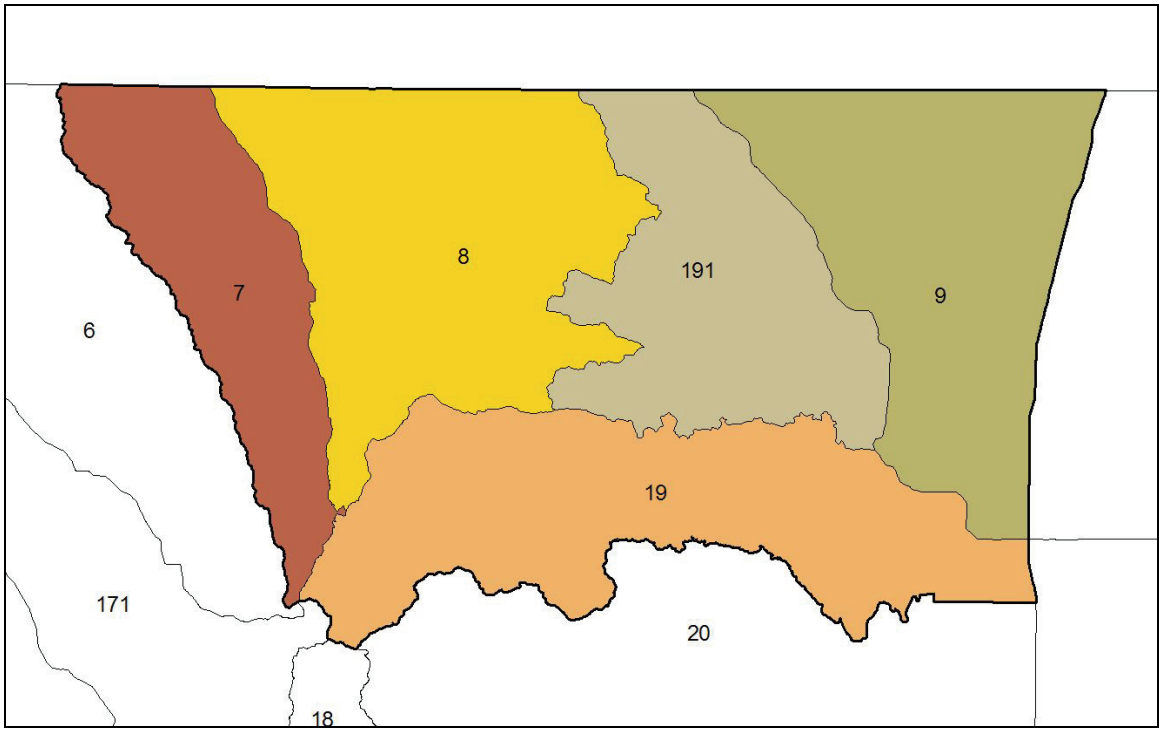


Figure 146. The area comprises one DAU and five GMUs (numbered black).

B. Project Partners

Participants involved in the project include the Habitat Model design team and the Northern Larimer County committee members. The design team consists of the following personnel: Gary Wockner- Research Associate and Modeler, Randy Boone - Research Scientist, Pat Tucker – HPP Coordinator. In addition to the design team, all members of the HPP committee were involved in creating the model, a process which took place over several meetings and presentations.

C. Data Sources

The Northern Larimer County project was the eleventh application of the Habitat Model and the fifteenth committee with which we worked. The management of elk and deer in the area historically has not caused considerable conflicts. The area has a several land management regimens including public and private owners. The data sources below represent the best fit for the needs of the model.

1. Production Values

Production values for the Northern Larimer County study area are composed of USDA-NRCS SSURGO data (described in Section III of this manual) and STATSGO data. The image below depicts the production map for the area.

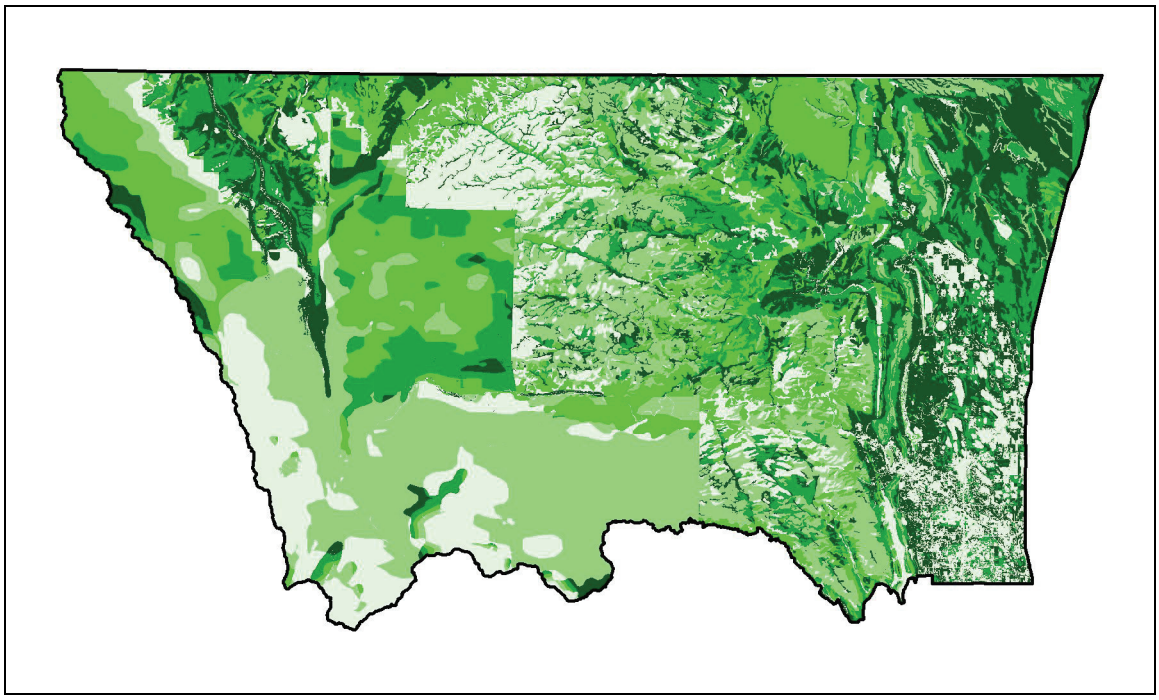


Figure 147. Production map for the Northern Larimer County HPP area. Darker color represents higher production values.

2. Winter Range Polygons

The winter range polygons for the Northern Larimer County committee area had recently been revised as part of the CDOW WRIS mapping project. Upon discussion with the HPP committee members, it was decided that the WRIS winter range polygons for elk and deer were accurate for the area and no further modification was necessary. Of the approximately 1.15 million acres in the study area, about 600,643 acres are elk and deer winter range. The map of winter range is below. Irrigated meadows and row crops are excluded from the winter range calculations.

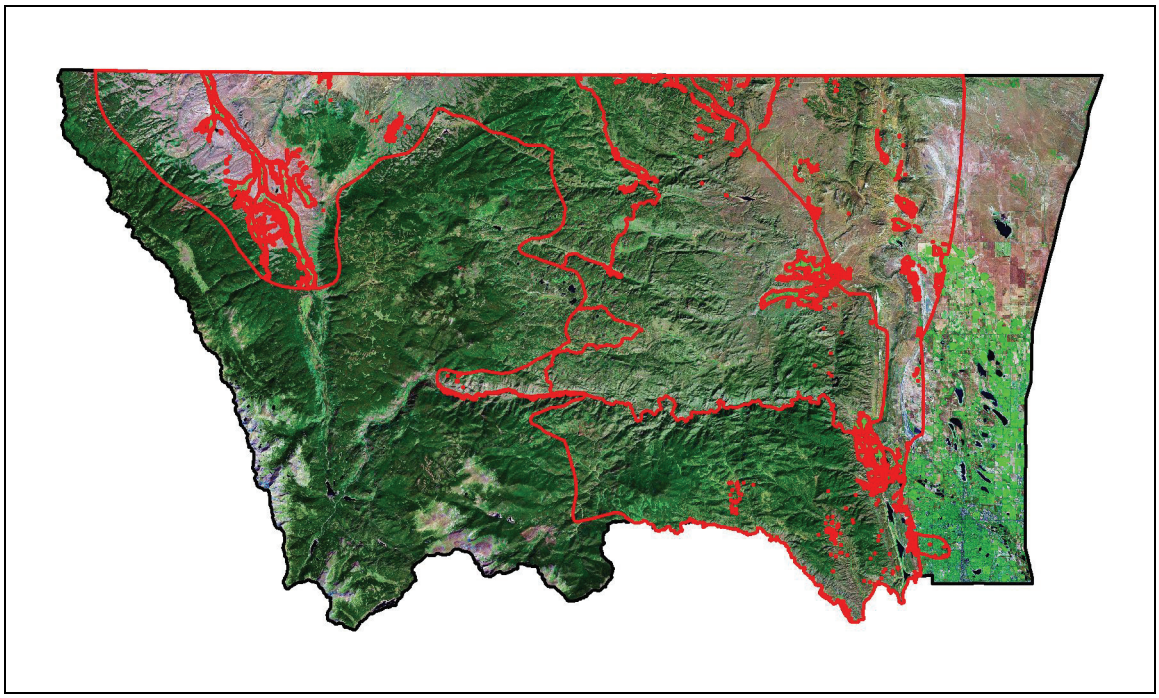


Figure 148. Red outline is elk and deer winter range.

3. Other Wild Ungulate Offtake

The Northern Larimer County area of the state also has grazing from wild ungulates including moose and pronghorn. The map below depicts the overall range of these two ungulate species, with the range of moose updated by CDOW personnel for this project. Although their range is somewhat significant, the number of animals and the size of the animals results in very low offtake in pounds per acre.

Figure 149. Offtake from moose (tan), and pronghorn (blue).

4. Livestock Offtake

The Northern Larimer County area has many livestock producers, and thus it was unfeasible to use the procedure used in the North and Middle Park, which was to contact each producer and obtain maps of the areas grazed. It was feasible, however, to get livestock numbers (cattle and sheep) from the State of Colorado Agricultural Statistics Service wherein livestock numbers are reported by county for all of Colorado.

Given this county-level data and the estimate from local ranchers, livestock offtake was refined by using satellite imagery which measures the vegetation's greenness across the landscape. These satellite images have been used throughout the world to predict livestock stocking rates by correlating the greenness visible on the landscape with the productivity of the vegetation, and therefore with the number of animals that can be supported. The map below spreads the county-level livestock offtake across the landscape as predicted by forage production and the greenness seen from satellite images through the year.

As per the requests of committee members, the Habitat Model can vary livestock offtake by the number of animals grazing. The details of this variation are discussed in Part D.

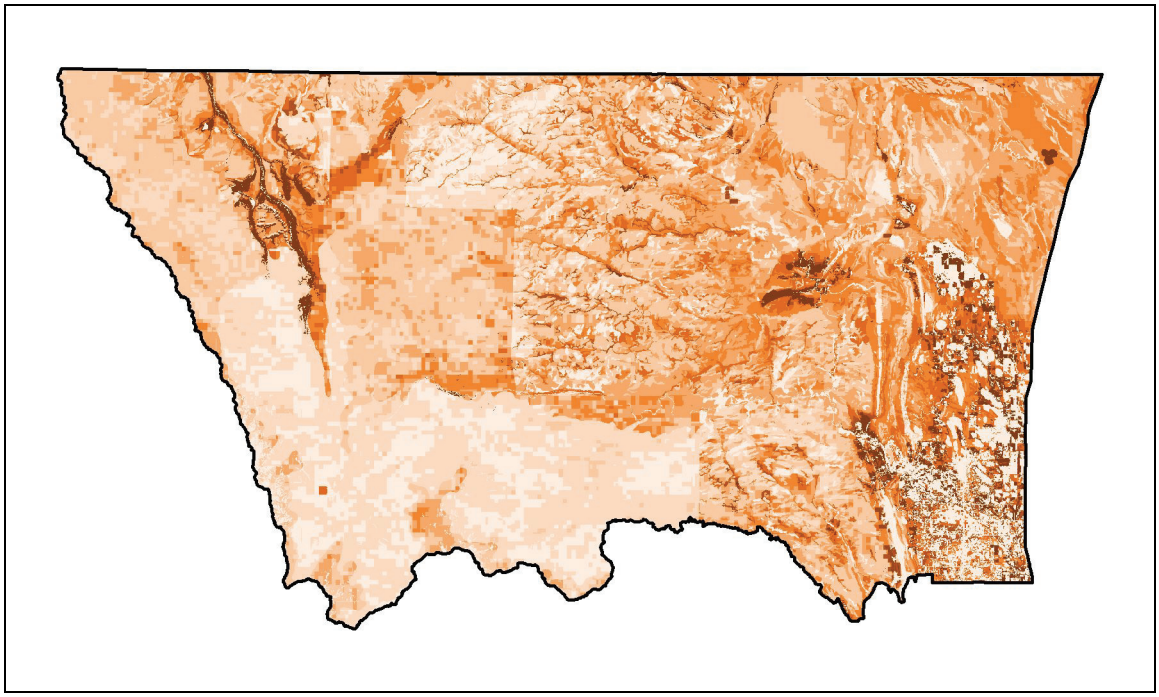


Figure 150. Livestock offtake predicted from satellite images and state statistics. The darker areas represent higher offtake.

D. Model Operation

After the model is installed (see Section VI), the Habitat Assessment Model menu item appears at the top menu bar in ArcView.

1. To start the model, click the Habitat Assessment Model menu item, and select "Run the Model."

2. The opening dialogue box, below, will appear. Click the "OK" button.

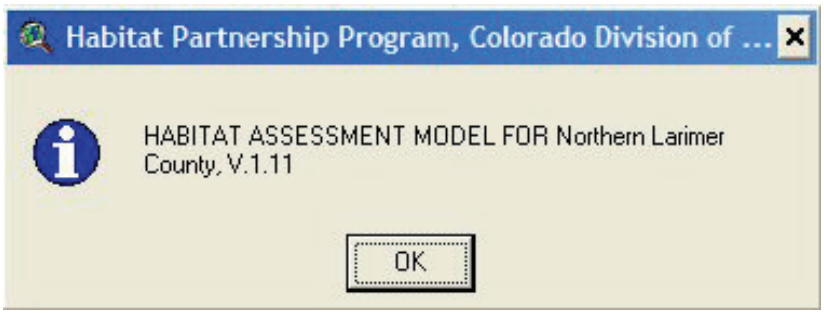


Figure 151. Opening Dialogue Box.

3. The next menu item that appears (below), the "Winter Utilization Areas," allows the user to select one of nine winter utilization areas to be modeled. These options include wintering areas within the whole study area (DAU 4) or five GMUs. This selection determines which winter range area, outlined in Section III, will be used in the modeling scenario.

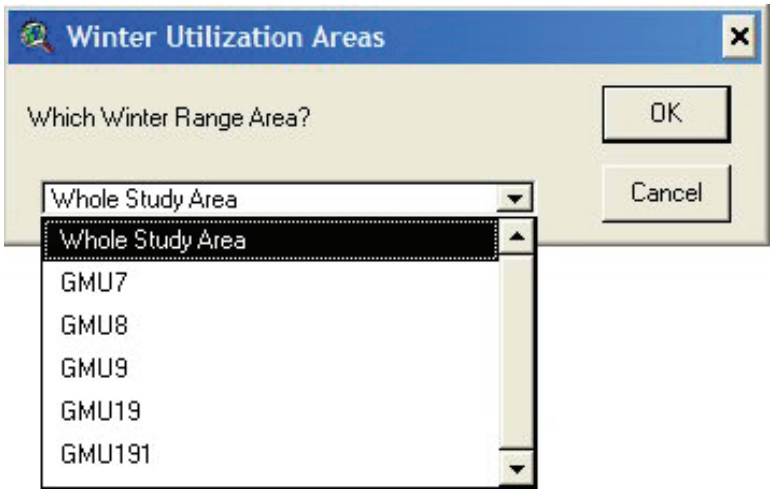


Figure 152. Winter Utilization Areas Dialogue Box.

4. The next menu choice, below, the "Prewinter Precipitation Patterns," provides the user with three precipitation patterns. This choice determines which production values, as described in Section III, will be used for wild ungulate population estimates. Mean, dry, and wet precipitation patterns correspond with average, below average, and above average forage production.

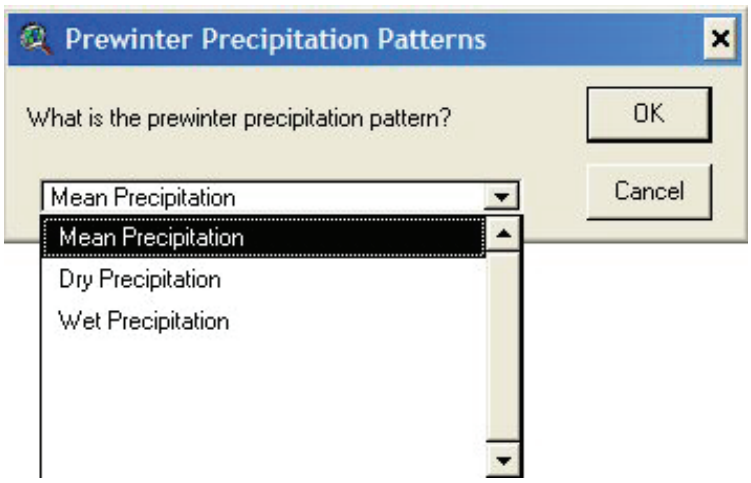


Figure 153. Prewinter Precipitation Dialogue Box.

5. The next choice is the "Livestock Grazing Intensity." Three choices are available – the "Livestock High in 1997," the "Livestock Ten-Year Average," and the "Livestock Low in 2002." The high in 1997, a very wet year, represents a historically high number of livestock that could be run on the landscape. The "Ten-Year Average" represents a medium number of livestock on the landscape, and the "Livestock Low in 2002" is a historic low, at the peak of a recent multi-year drought.

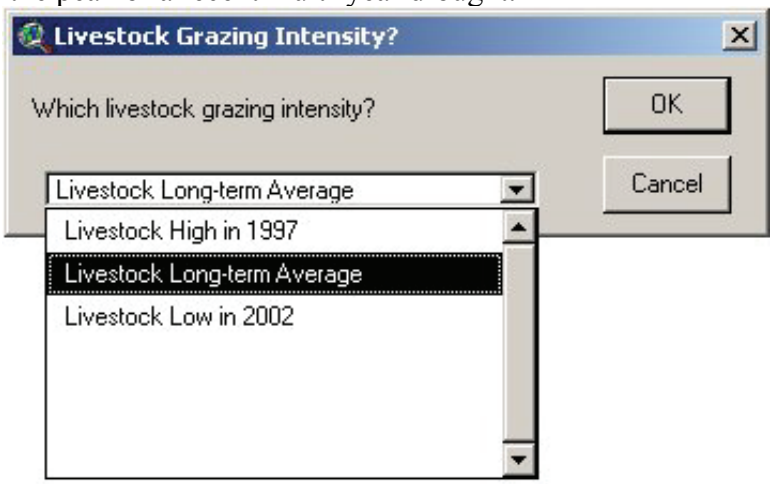


Figure 154. Livestock Grazing Intensity Dialogue Box.

6. The "Elk and Deer Utilization Period,"—the next menu item, below—allows the user to determine how many months per year elk and deer are using the chosen study area. For the whole study area, it appears that "6 months" is the most likely scenario. But, on smaller GMUs here and there, differences may occur.

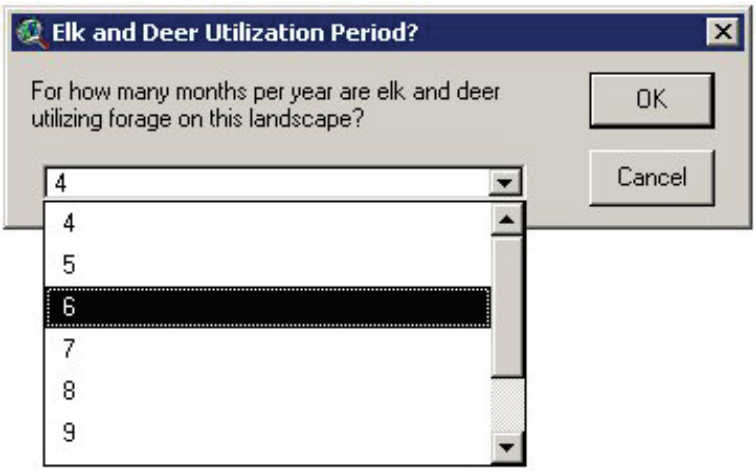


Figure 155. Elk and Deer Utilization Period Dialogue Box.

E. Habitat Model Results for the Northern Larimer HPP Area

Because the Habitat Model in the Northern Larimer County area has been developed to run for multiple GMUs, and with several variables, many different results tables can be generated. In the discussion below we present two of the potential results tables with some associated interpretation.

The entire North Fork study area currently has an estimated 3,800 elk and 5,600 deer, which comes out to approximately 40% elk and 60% deer, and thus the corresponding row in the tables is highlighted in yellow.

Figure 156 below offers results for the whole study area, winter range, mean precipitation, livestock long-term average, and 6 months of wildlife on the winter range.

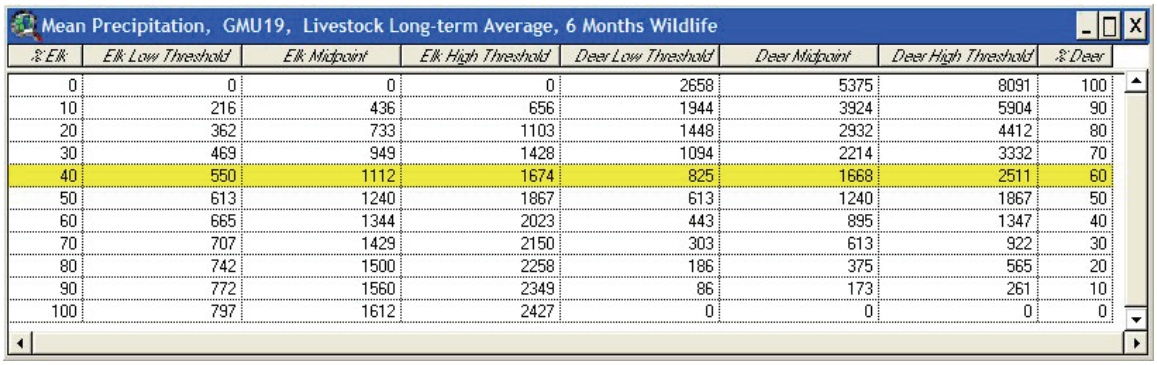
Mean Precipitation, Whole Study Area, Livestock Long-term Average, 6 Months Wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	3956	23836	43716	100
10	321	1933	3545	2889	17397	31905	90
20	539	3250	5961	2156	13000	23844	80
30	698	4207	7715	1628	9815	17999	70
40	819	4932	9045	1229	7398	13568	60
50	913	5501	10088	913	5501	10088	50
60	989	5960	10931	659	3969	7280	40
70	1052	6335	11619	451	2718	4985	30
80	1104	6652	12200	276	1663	3050	20
90	1149	6920	12692	128	768	1409	10
100	1187	7151	13115	0	0	0	0

Figure 156. Sample Results for the Whole Study Area specified by the table title.

The results in Figure 156, for the winter range, suggest that the current numbers of elk and deer are slightly below the middle threshold. This suggests that the range in the Northern Larimer County area is not being over-grazed, but is roughly at or slightly below "carrying capacity" situation. Over the last decade many elk and deer have been

harvested in the area due to research on chronic wasting disease – this may explain why wildlife numbers are somewhat below carrying capacity.



Mean Precipitation, GMU19, Livestock Long-term Average, 6 Months Wildlife

% Elk	Elk Low Threshold	Elk Midpoint	Elk High Threshold	Deer Low Threshold	Deer Midpoint	Deer High Threshold	% Deer
0	0	0	0	2658	5375	8091	100
10	216	436	656	1944	3924	5904	90
20	362	733	1103	1448	2932	4412	80
30	469	949	1428	1094	2214	3332	70
40	550	1112	1674	825	1668	2511	60
50	613	1240	1867	613	1240	1867	50
60	665	1344	2023	443	895	1347	40
70	707	1429	2150	303	613	922	30
80	742	1500	2258	186	375	565	20
90	772	1560	2349	86	173	261	10
100	797	1612	2427	0	0	0	0

Figure 157. Results Table based DAU 20.

The results in Figure 157 are for GMU 19. These numbers roughly correspond with the on-the-ground estimate for elk and deer in the GMU.

Given that the model suggests that the North Fork study area is being grazed at or near carrying capacity, we could then suggest that, on an area-wide basis, if there are conflicts occurring between wildlife and livestock, those conflicts are more likely to be caused by the distribution of animals on the range (overlapping ranges, periods of grazing) instead of an overabundance of animals. Likewise, the programs and manipulations employed by HPP to deal with overlapping ranges and periods of grazing are likely a better solution to addressing conflicts than to consider drastic changes in the hunting quotas of elk and deer.

Using the results table generated in Figure 156, we can create a breakdown of how the forage was allocated across the winter range landscape.

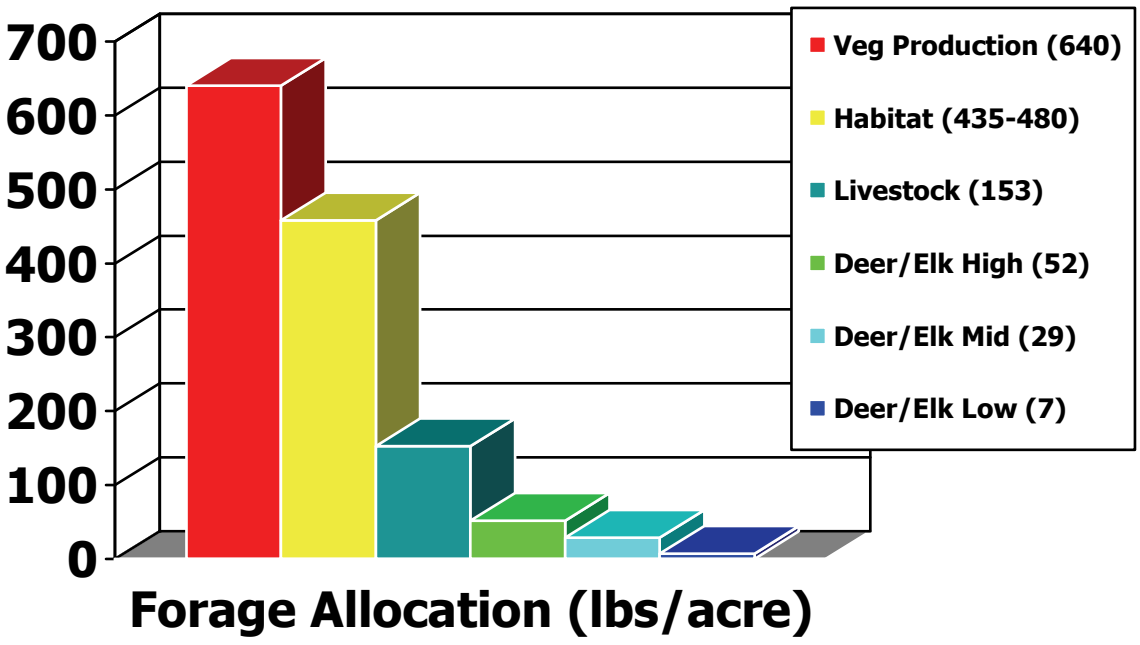


Figure 158. Forage Allocation using the results table in Figure 156.

Figure 158 depicts the amount of forage that is allocated to each forage utilization component in the model. In the winter range, the average forage production was 640 pounds per acre. The habitat retained between 435 and 480 pounds to ensure sustainability. Livestock (ten-year average) consumed 153 pounds per acre, and deer and elk offtake varied by the threshold level.

The model also has available menu options to run on the other GMUs in the study area. Each of these model results can be compared to CDOW's objectives and estimates in each unit. Many additional results tables can be generated based on committee needs and interests. With all the variables in the model, fine scale questions can be answered and management objectives can hopefully be equally attuned.