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.
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 scabra* 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
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.
http://soildatamart.nrcs.usda.gov/
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.

![SMART Board Mapping Process](image)

**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).

![Winter Range Polygons](image)

**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.

<table>
<thead>
<tr>
<th>Wild Ungulate</th>
<th>Average Body Weight per Individual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pronghorn Antelope</td>
<td>100 lbs</td>
</tr>
<tr>
<td>Moose</td>
<td>1000 lbs</td>
</tr>
<tr>
<td>Elk</td>
<td>500 lbs</td>
</tr>
<tr>
<td>Mule Deer</td>
<td>150 lbs</td>
</tr>
</tbody>
</table>

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.

\[
\begin{align*}
250 \text{ Pronghorn} \times 2 \text{ lbs per day} \times 365 \text{ days per year} &= 182500 \text{ lbs of forage per year} \\
(100 \text{ lb average weight}) \times (2\%)
\end{align*}
\]

**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-](image)

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.

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.

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 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.

<table>
<thead>
<tr>
<th>Low Threshold</th>
<th>High Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Decreased intraspecific competition</td>
<td>• Increased intraspecific competition</td>
</tr>
<tr>
<td>• More resources per individual</td>
<td>• Fewer resources per individual</td>
</tr>
<tr>
<td>• Higher offspring survival</td>
<td>• Decreased performance per animal</td>
</tr>
<tr>
<td>• More weight gain</td>
<td></td>
</tr>
<tr>
<td>• Faster recovery from lactation</td>
<td></td>
</tr>
</tbody>
</table>

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 Habitat_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](image)

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.

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 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.

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](image)

This window signals the user that they have 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](image)

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.
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

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.

![Figure 19. Output Table Containing Zero Value Fields](image)

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:


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 °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.

<table>
<thead>
<tr>
<th>Vegetation Type</th>
<th>Percent Cover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sagebrush Grassland</td>
<td>41</td>
</tr>
<tr>
<td>Forests</td>
<td>44</td>
</tr>
<tr>
<td>Irrigated Hayfields</td>
<td>8</td>
</tr>
</tbody>
</table>

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\textsuperscript{1} - Project Lead  
Gary Wockner\textsuperscript{2} - Research Associate and Modeler  
Erik Hardy\textsuperscript{2} - Research Associate  
Steve Porter\textsuperscript{3} - HPP Coordinator and Technical Advisor  
N.T. Hobbs\textsuperscript{2} - Technical Advisor  
Dave Freddy\textsuperscript{3} - Technical Advisor

North Park HPP committee members include:

Landowner Representatives:  
Danny Meyring  
Blaine Evans  
James Baller, Jr.  

Division of Wildlife Representative:  
Kirk Snyder

Sportsmen Representative:  
Todd Peterson, Chairman

US Fish & Wildlife Service Representative:  
Mark Lanier

Bureau of Land Management Representative:  
Chuck Oliver, District Ranger

Dave Harr, Assistant Manager

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

\textsuperscript{1} Forest, Range, and Watershed Stewardship Department, Colorado State University  
\textsuperscript{2} Natural Resource Ecology Lab, Colorado State University  
\textsuperscript{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:

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.

<table>
<thead>
<tr>
<th>Region</th>
<th>Area (Acres)</th>
<th>Offtake per Acre (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>378,492</td>
<td>131</td>
</tr>
<tr>
<td>2</td>
<td>141,607</td>
<td>151</td>
</tr>
<tr>
<td>3</td>
<td>166,349</td>
<td>172</td>
</tr>
<tr>
<td>4</td>
<td>98,796</td>
<td>174</td>
</tr>
<tr>
<td>5</td>
<td>158,180</td>
<td>232</td>
</tr>
<tr>
<td>6</td>
<td>93,401</td>
<td>120</td>
</tr>
</tbody>
</table>

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

D. Habitat Model Results

Entire County Results

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.

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](image)

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

![Figure 26. Entire Subherd Sample Results](image)
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).

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 complement 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.

![GMUs for the Middle Park Study Area](image)

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:

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

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

![Figure 29. Model Output for the Middle Park Study Area](output)

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.](image)

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.

![Figure 31. Model Results for Elk DAU 13](image)
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.

![Map of GMUS for the Northwest Study Area](image)

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.](image-url)
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:

![Map showing winter range polygons]

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.
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.
D. Model Operation
Because the Northwest model operation is a bit more complicated than the stock version which was used in North and Middle Park, 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.
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.](image)

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.](image)
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.](image)

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.](image)
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.

![Livestock Utilization Period Dialogue Box](image)

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.

![Wildlife Utilization Period Dialogue Box](image)

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.

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).

<table>
<thead>
<tr>
<th>Northwest Elk and Mule Deer Numbers (DAU 1,2,6,7)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source</strong></td>
</tr>
<tr>
<td>Objective</td>
</tr>
<tr>
<td>Current estimate</td>
</tr>
</tbody>
</table>

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

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.

![Figure 47. Results Table based on Ten-Year Average Livestock.](image)

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.](image)
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.

![Figure 49. Sample results for DAU 2.](image)

![Figure 50. Sample results for DAU 7.](image)

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 area 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 Woodward, 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.

![Production map for the San Luis Valley.](image-url)
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.

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.
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.
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.
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.](image)

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.](image)

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.

![Prewinter Precipitation Dialogue Box.](image)

**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.

![Livestock Grazing Intensity Dialogue Box.](image)

**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.

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.
E. Habitat Model Results for the San Luis Valley Colorado

Because the Habitat Model in the San Luis 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.

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.

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.

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.](image)

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.](image)

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.
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.
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.
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.

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.
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.

![Figure 76. Livestock Grazing Intensity Dialogue Box.](image)

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.](image)
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.

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.
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 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.
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.
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.
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.

![Opening Dialogue Box](image)

**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.

![Winter Range or Severe Winter Range](image)

**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.
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.

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.

<p>| Mean Precipitation, Winter Range, Whole Study Area, Livestock Long-term Average, 6 Months Wildlife |
|---------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|</p>
<table>
<thead>
<tr>
<th>% EL</th>
<th>EL Low Threshold</th>
<th>EL Median</th>
<th>EL High Threshold</th>
<th>Cowa Low Threshold</th>
<th>Cowa Median</th>
<th>Cowa High Threshold</th>
<th>% Cowa</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>59,761</td>
<td>102,295</td>
<td>151,628</td>
</tr>
<tr>
<td>10%</td>
<td>4,259</td>
<td>14,004</td>
<td>25,077</td>
<td>22,934</td>
<td>59,291</td>
<td>78,453</td>
<td>116,486</td>
</tr>
<tr>
<td>20%</td>
<td>9,408</td>
<td>18,124</td>
<td>25,079</td>
<td>22,956</td>
<td>58,281</td>
<td>78,453</td>
<td>116,486</td>
</tr>
<tr>
<td>30%</td>
<td>11,933</td>
<td>21,487</td>
<td>31,771</td>
<td>27,697</td>
<td>55,808</td>
<td>78,453</td>
<td>116,486</td>
</tr>
<tr>
<td>40%</td>
<td>13,018</td>
<td>23,592</td>
<td>39,991</td>
<td>34,931</td>
<td>53,086</td>
<td>78,453</td>
<td>116,486</td>
</tr>
<tr>
<td>50%</td>
<td>15,063</td>
<td>25,670</td>
<td>47,913</td>
<td>43,053</td>
<td>50,269</td>
<td>78,453</td>
<td>116,486</td>
</tr>
<tr>
<td>60%</td>
<td>17,004</td>
<td>27,885</td>
<td>55,939</td>
<td>51,030</td>
<td>47,453</td>
<td>78,453</td>
<td>116,486</td>
</tr>
<tr>
<td>70%</td>
<td>19,001</td>
<td>29,000</td>
<td>63,965</td>
<td>59,001</td>
<td>44,643</td>
<td>78,453</td>
<td>116,486</td>
</tr>
<tr>
<td>80%</td>
<td>21,000</td>
<td>30,181</td>
<td>71,991</td>
<td>66,963</td>
<td>41,836</td>
<td>78,453</td>
<td>116,486</td>
</tr>
<tr>
<td>90%</td>
<td>23,000</td>
<td>31,362</td>
<td>79,017</td>
<td>74,981</td>
<td>39,029</td>
<td>78,453</td>
<td>116,486</td>
</tr>
<tr>
<td>100%</td>
<td>25,000</td>
<td>32,543</td>
<td>87,043</td>
<td>82,001</td>
<td>36,223</td>
<td>78,453</td>
<td>116,486</td>
</tr>
</tbody>
</table>

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.
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 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.](image)

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.

![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.](image)

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.

![Winter range polygons for Southwest HPP area.](image)
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.
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.](image)

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.](image)

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.
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.

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.
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.

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.

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 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.

![Map of Grand Mesa study area](image)

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.

![Production map for Grand Mesa HPP area. Darker green color represents higher production values.](image-url)
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.](image)

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.

**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.
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.

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.
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.

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.
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.

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.
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 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.

![Production map for the Uncompahgre HPP area. Darker color represents higher production values.](image-url)

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.

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.
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.
**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.
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.

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.
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.

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.
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.

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.
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 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.

![Production map for the North Fork Gunnison HPP area. Darker color represents higher production values.](image-url)
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.](image)

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.
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.

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

**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.](image)
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.](image1)

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.](image2)

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.

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.

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 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, 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).](image)

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.

![Production map for the Northern Larimer County HPP area. Darker color represents higher production values.](image)

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 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.
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. 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.
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.

![Habitat Partnership Program, Colorado Division of …](image)

**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, 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.

![Winter Utilization Areas](image)

**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.
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.

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.
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.

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.

![Figure 157. Results Table based DAU 20.](image)

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.
Appendix 12. Arkansas Valley Habitat Assessment Model Case Study

A. Location

The Arkansas Valley HPP study area comprises about 2.76 million acres in the south central part of Colorado. The Arkansas Valley study area includes one HPP committee boundary: Arkansas Valley. The area includes the three deer DAUs 15, 16, and 50, and the three elk DAUs 17, 22, and 23. The area includes twelve GMUs 48, 481, 56, 561, 49, 57, 58, 581, 511, 512, 59, 591.

The study area includes parts of eight counties. In addition to significant amounts of privately owned land, the study area contains lands administered by the BLM, USFS and State Wildlife Areas.

Figure 159. The area comprises three DAUs and twelve GMUs.

B. Project Partners

Participants involved in the project include the Habitat Model design team and the Arkansas Valley 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 Arkansas Valley project was the twelfth application of the Habitat Model and the sixteenth 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 Arkansas Valley 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.

![Production Map](image1)

Figure 160. Production map for the Arkansas Valley HPP area. Darker color represents higher production values.

2. Winter Range Polygons
The winter range polygons for the Arkansas Valley 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 2.76 million acres in the study area, about 1.8 million 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.

![Map of winter range with red outline indicating elk and deer winter range](image)

**Figure 161.** Red outline is elk and deer winter range.

### 3. Other Wild Ungulate Offtake

The Arkansas Valley area of the state also has grazing from wild ungulates including moose, pronghorn, mountain goats, and bighorn sheep. The map below depicts the overall range of these four 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.
4. Livestock Offtake

The Arkansas Valley 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.
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.
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 12 GMUs. This selection determines which winter range area, outlined in Section III, will be used in the modeling scenario.

![Figure 165. Winter Utilization Areas Dialogue Box.](image)

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 166. Prewinter Precipitation Dialogue Box.](image)

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.

![Livestock Grazing Intensity Dialogue Box](image)

**Figure 167. 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.

![Elk and Deer Utilization Period Dialogue Box](image)

**Figure 168. Elk and Deer Utilization Period Dialogue Box.**

**E. Habitat Model Results for the Arkansas Valley HPP Area**

Because the Habitat Model in the Arkansas Valley area has been developed to run for all three DAUs and all twelve GMUs, and with several variables, dozens of different results tables can be generated. Also, because the area is very, very large, we are more confident in the results for the whole area and for thee three DAUs. Conversely, the results for each GMU have confidence intervals that are very wide, and thus we caution interpretation.
based on GMU results. In the discussion below we present four of the potential results – the whole area and for the three DAUS, with tables and some associated interpretation.

The entire Arkansas Valley study area currently has an estimated 7,072 elk and 22,163 deer, which comes out to approximately 25% elk and 75% deer, and thus the corresponding rows in the tables is highlighted in yellow.

Figure 169 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.

![Figure 169. Sample Results for the Whole Study Area specified by the table title.](image)

The results in Figure 169, for the winter range, suggest that the current numbers of elk and deer are about at the middle threshold. This suggests that the range in the Arkansas Valley area is not being over-grazed, but is roughly at “carrying capacity.”

DAU15 results are in Figure 170, below. DAU15 currently has around 2,420 elk and 6,090 deer, or about 30% elk and 70% deer. Figure 170 below for the winter range suggests that DAU15 is slightly below carrying capacity.

![Figure 170. Sample Results for the DAU15 specified by the table title.](image)

DAU16 results are in Figure 171, below. DAU16 currently has around 2,752 elk and 12,083 deer, or about 20% elk and 80% deer. Figure 171 below for the winter range suggests that DAU16 is roughly at carrying capacity.

![Figure 171. Sample Results for the DAU16 specified by the table title.](image)
DAU50 results are in Figure 172, below. DAU50 currently has around 1,900 elk and 3,990 deer, or about 30% elk and 70% deer. Figure 172 below for the winter range suggests that DAU50 is roughly at carrying capacity.

Given that the model suggests that the Arkansas Valley 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 169, we can create a breakdown of how the forage was allocated across the winter range landscape.
Figure 173. Forage Allocation using the results table in Figure 156.

Figure 173 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 484 pounds per acre. The habitat retained between 329 and 363 pounds to ensure sustainability. Livestock (ten-year average) consumed 134 pounds per acre, and deer and elk offtake varied by the threshold level.
Appendix 13. Sangre de Cristo Habitat Assessment Model Case Study

A. Location

The Sangre de Cristo HPP study area comprises about 2.94 million acres in the south central part of Colorado. The Sangre de Cristo study area includes one HPP committee boundary: Sangre de Cristo. The area includes the two deer DAUs 32 and 34, and the three elk DAUs 27, 28, and 33. The area includes eight GMUs 86, 691, 69, 84, 861, 85, 851, 140.

The study area includes parts of seven counties. In addition to significant amounts of privately owned land, the study area contains lands administered by the BLM, USFS and Colorado State Wildlife Areas.

B. Project Partners

Participants involved in the project include the Habitat Model design team and the Sangre de Cristo committee members. The design team consists of the following personnel: Gary Wockner - Research Associate and Modeler, Randy Boone - Research Scientist, Pat
C. Data Sources

The Sangre de Cristo project was the thirteenth application of the Habitat Model and the seventeenth committee with which we worked. The management of elk and deer in the area historically has not caused considerable conflicts, although elk conflicts do occur in the north section of the area, in GMUs 69 and 691. 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 Sangre de Cristo 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, in a year of average precipitation.

![Production map for the Sangre de Cristo HPP area. Darker color represents higher production values.](image)

2. Winter Range Polygons
The winter range polygons for the Sangre de Cristo 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 2.94 million acres in the study area, about 2.26 million 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 176. Red outline is elk and deer winter range.](image)

### 3. Other Wild Ungulate Offtake

The Sangre de Cristo area of the state also has grazing from wild ungulates, including pronghorn and bighorn sheep. 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.
4. Livestock Offtake

The Sangre de Cristo 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, 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.
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.
3. The next menu item that appears (below), the “Winter Utilization Areas,” allows the user to select one of three winter utilization areas to be modeled. These options include wintering areas within the whole study area, and either of the two deer DAUs. This selection determines which winter range area, outlined in Section III, will be used in the modeling scenario.

![Figure 180. Winter Utilization Areas Dialogue Box.](image)

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 181. Prewinter Precipitation Dialogue Box.](image)

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.

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 areas of study, differences may occur.

E. Habitat Model Results for the Sangre de Cristo HPP Area

Because the Habitat Model in the Sangre de Cristo area has been developed to run for the whole study area and for both deer DAUs with several variables, several different results tables can be generated. Also, because the area is very, very large, we are more confident in the results for the whole area and for the two DAUs. The committee chose not to develop the model to run on individual GMUs, as has been done in other areas. In the
discussion below we present three of the potential results – the whole area and for the two DAUS, with tables and some associated interpretation.

The entire Sangre de Cristo study area currently has an estimated 11,835 elk and 22,070 deer, which comes out to approximately 36% elk and 64% deer, and thus the corresponding rows in the tables is highlighted in yellow.

Figure 184 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.

The results in Figure 184, for the winter range, suggest that the current numbers of elk and deer are about at the middle threshold. This suggests that the range in the Arkansas Valley area is not being over-grazed, but is roughly at “carrying capacity.”

Deer DAU32 results are in Figure 185, below. DAU32 currently has around 8,565 elk and 4,820 deer, or about 60% elk and 40% deer. Figure 185 below for the winter range suggests that DAU15 is slightly above carrying capacity.

DAU34 results are in Figure 186, below. DAU34 currently has around 3,270 elk and 17,250 deer, or about 15% elk and 85% deer. Figure 171 below for the winter range suggests that DAU34 is slightly below carrying capacity.
Given that the model suggests that the Sangre de Cristo 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 184, we can create a breakdown of how the forage was allocated across the winter range landscape, in Figure 187 below.
Figure 187 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 557 pounds per acre per year. The habitat retained between 378 and 418 pounds to ensure sustainability. Livestock (ten-year average) consumed 153 pounds per acre, and deer and elk offtake varied by the threshold level.
Appendix 14. Lower Colorado Habitat Assessment Model Case Study

A. Location

The Lower Colorado HPP study area comprises about 2.46 million acres in the central part of Colorado. The Lower Colorado study area includes one HPP committee boundary: Lower Colorado. The area includes the all or part of six deer DAUs 8, 13, 14, 42, 43, 53, and all or part of the four elk DAUs 6, 12, 13, 16. The area includes twelve GMUs 25, 26, 33, 34, 35, 36, 43, 44, 45, 47, 444, and 471.

The study area includes parts of seven counties. In addition to significant amounts of privately owned land, the study area contains lands administered by the BLM, USFS and Colorado State Wildlife Areas.

![Figure 188. The area comprises six deer DAUs and twelve GMUs.](image)

B. Project Partners

Participants involved in the project include the Habitat Model design team and the Lower Colorado committee members. The design team consists of the following personnel:
C. Data Sources

The Lower Colorado project was the fourteenth application of the Habitat Model and the eighteenth 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 Lower Colorado study area are composed of USDA-NRCS SSURGO data (described in Section III of this manual) and STATSGO data. Fine-scale soils data were published for parts of Routt County in September of 2007, building on soils maps released in 2006. For areas mapped at high resolution in Garfield and Eagle Counties, those mapping efforts began in 1999, with the final maps published in February of 2008. The image below depicts the production map for the area, in a year of average precipitation.

![Production map for the Lower Colorado HPP area. Darker color represents higher production values.](image)
2. Winter Range Polygons
The winter range polygons for the Lower Colorado 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 2.46 million acres in the study area, about 920,000 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.

3. Other Wild Ungulate Offtake
The Lower Colorado area of the state also has grazing from wild ungulates, including pronghorn, bighorn sheep, moose, and mountain goats. The map below depicts the overall range of these four 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.
4. Livestock Offtake

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

![Figure 194. Winter Utilization Areas Dialogue Box.](image)

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 195. Prewinter Precipitation Dialogue Box.](image)

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.

![Livestock Grazing Intensity Dialogue Box.](Image)

**Figure 196. 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 areas of study, differences may occur.

![Elk and Deer Utilization Period Dialogue Box.](Image)

**Figure 197. Elk and Deer Utilization Period Dialogue Box.**

E. Habitat Model Results for the Lower Colorado HPP Area

Because the Habitat Model in the Lower Colorado area has been developed to run for the whole study area and for all six deer DAUs with several variables, dozens of different results tables can be generated. In the discussion below we present just one of the potential results for the whole study area, and we also summarize the results for each of the DAUs.
The entire Lower Colorado study area currently has an estimated 26,883 elk and 47,695 deer, which comes out to approximately 36% elk and 64% deer, and thus the corresponding rows in the tables is highlighted in yellow.

Figure 198 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.

![Figure 198](image)

Figure 198. Sample Results for the Whole Study Area specified by the table title.

The results in Figure 198, for the winter range, suggest that the current numbers of elk and deer are about at the middle threshold. This suggests that the range in the Lower Colorado HPP area is not being over-grazed, but is roughly at “carrying capacity.”

Given that the model suggests that the Lower Colorado 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.

Figure 199, below displays the current estimates for elk and deer in each DAU of the HPP study area as determined by CDOW using the flights and population estimates. For each DAU, the estimate produced by the Habitat Assessment Model are also roughly equivalent (all of the DAU results are not shown, but can be run by the model). This suggests again that each of the DAUs are also roughly at “carrying capacity” and that if there are conflicts on the range in any DAU in the study area, that those conflicts are likely caused by the distribution of animals 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.
Current Estimates of Elk and Deer in each DAU

<table>
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<th>Elk</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>9600</td>
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<tr>
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<td>5010</td>
</tr>
<tr>
<td>8720</td>
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</tr>
<tr>
<td>9850</td>
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</tr>
<tr>
<td>5810</td>
<td>all</td>
</tr>
<tr>
<td>47695</td>
<td>26883</td>
</tr>
</tbody>
</table>

Total 47695 26883

Figure 199. Current estimates for elk and deer in each DAU of the Lower Colorado HPP area.

Using the results table generated in Figure 198, we can create a breakdown of how the forage was allocated across the winter range landscape, in Figure 200 below.

![Forage Allocation](image)

Figure 200. Forage Allocation using the results table in Figure 198.

Figure 200 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 815 pounds per acre per year. The habitat retained between 554 and 611 pounds to ensure sustainability. Livestock (ten-year average) consumed 194 pounds per acre, and deer and elk offtake varied by the threshold level.