Teton Ungulate Modeling Project

Using data and models to inform management decisions.

My name is Tom Hobbs and I am a ecologist at the Natural Resource Ecology Laboratory at Colorado State University. My colleagues and I are working to quantify how many native ungulates be supported by winter habitats in the Greater Teton Ecosystem. What I want to do today is to give you a progress report on our work to date.

The overarching goal of our project is to bring together data and models to support decisions on ungulate management. In particular we want to help understand the consequences of different alternatives for managing densities of ungulate populations.

Goals for First Year

- Build a forage accounting model.
- Include suggestions from managers.
- Address key questions.

Our first objective was to build a forage accounting model. I'll tell you more about how the model works later.

Our second objective was to modify the model to reflect suggestions from land and wildlife managers. Last August we met with representatives from the National Elk Refuge, the U.S. Forest Service and the Wyoming Fish and Game, to show them a prototype model and to listen to their suggestions for improvement. Since then we have been working to incorporate those suggestions in our model.

Our third objective was to use our forage accounting model to answer questions about the ability of habitats to support ungulates in the Greater Teton Ecosystem.

Key Questions

- Population size and feeding requirements?
- Does feeding compensate for habitat loss?
- Impacts of continued increases in bison population?
- Consequences of livestock grazing?

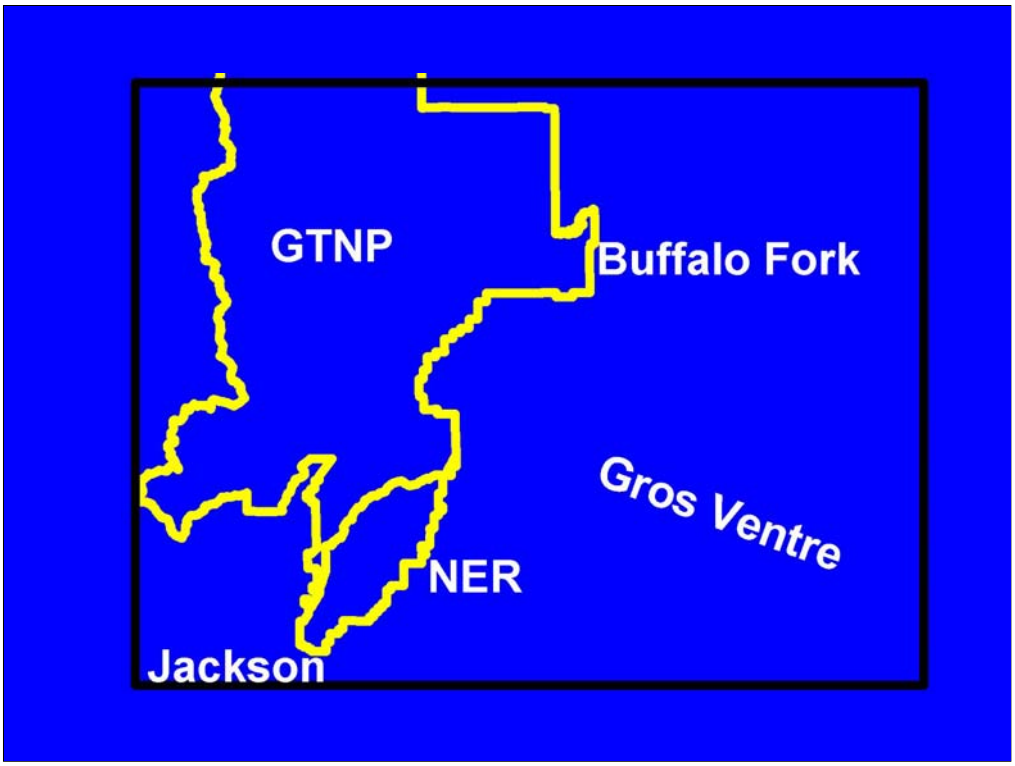
So, let me talk just a bit about those questions.

Our first question was how does the population size of elk affect the need to provide supplement feed?

Second, we asked, does supplemental feeding compensate for forage lost to development in the town of Jackson.

We then examined the affect of increased bison number on forage supplies

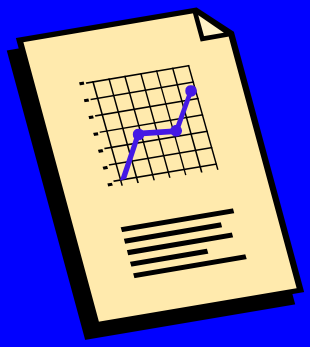
And finally we examined the effect of eliminating livestock during summer on forage supplies during winter .



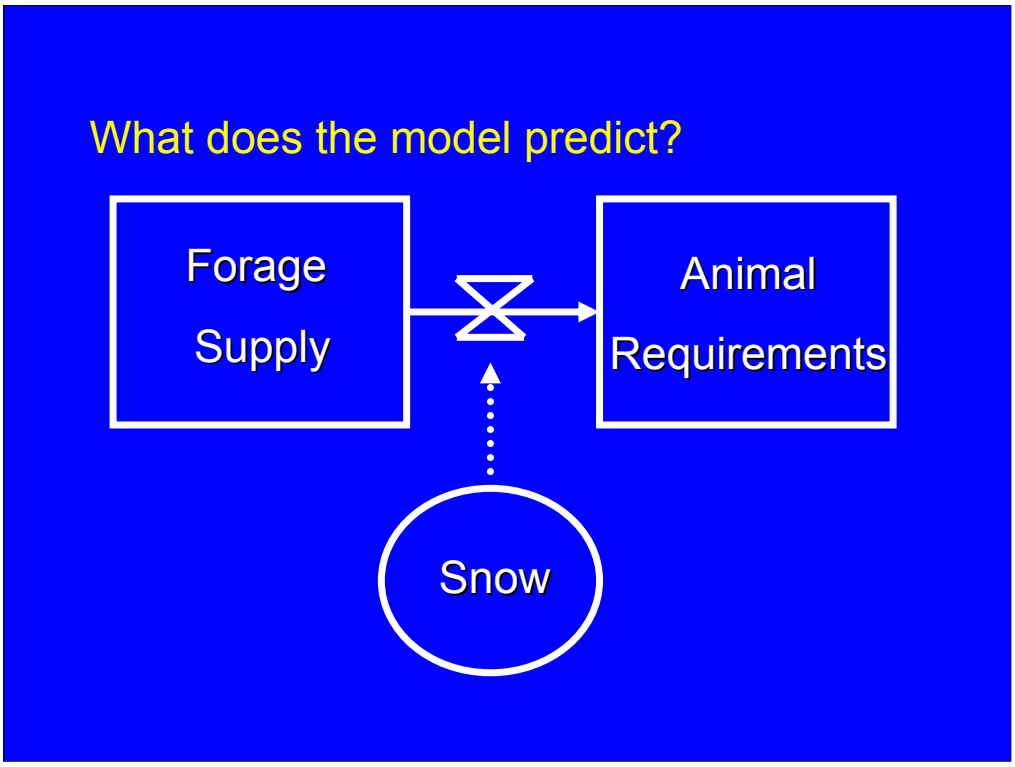
Our study area is show by the black outline. It includes most of Grand Teton Park the National Elk Refuge, the Gross Ventre Valley and Buffalo Fork.

A Forage Accounting Model

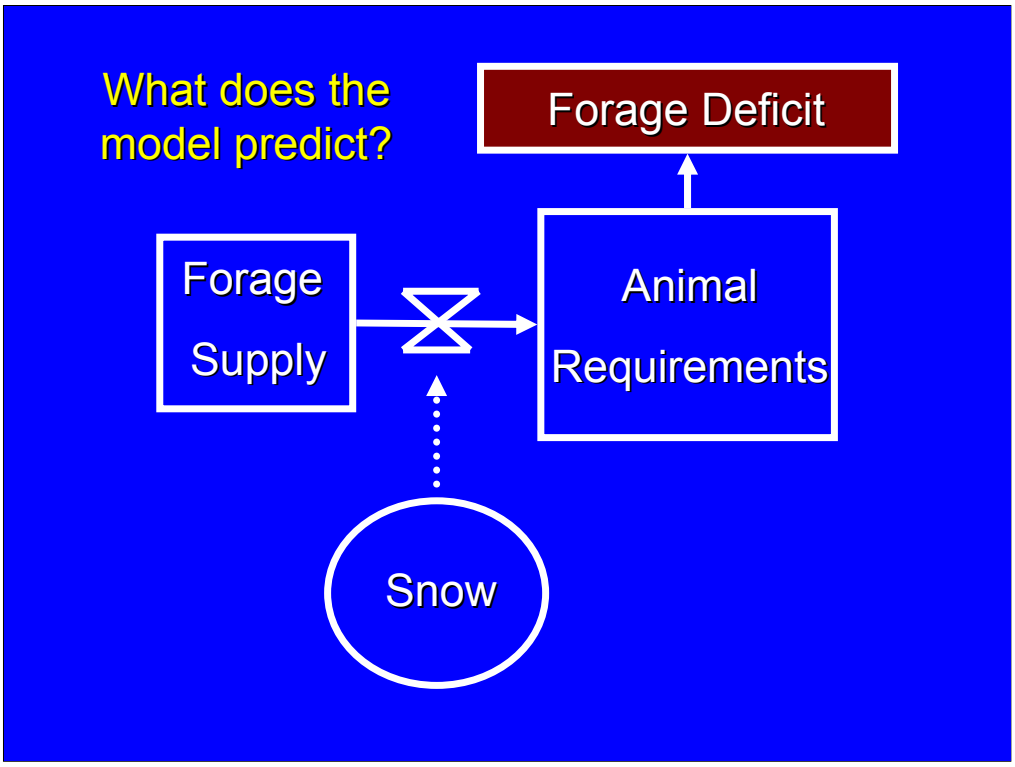
- What does it predict?
- How does it work?



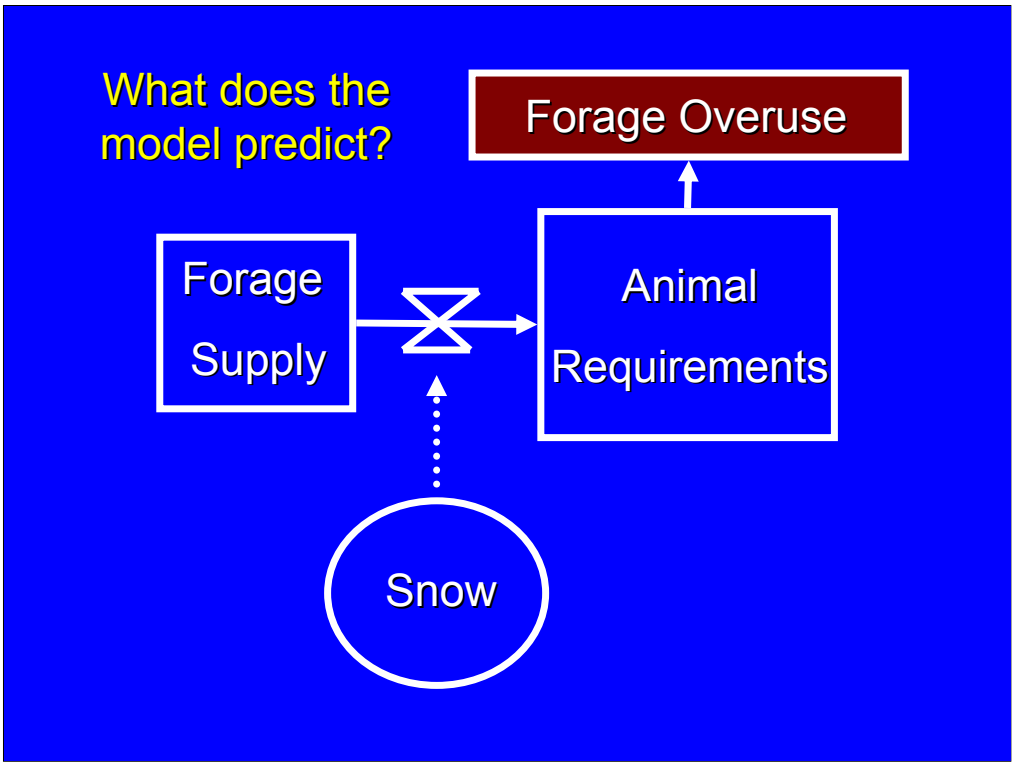
If you are going to have faith in the predictions of our model then you need to understand something about how it works. So, I'll give you an overview of what the model predicts and then I will describe how it arrives at those predictions.



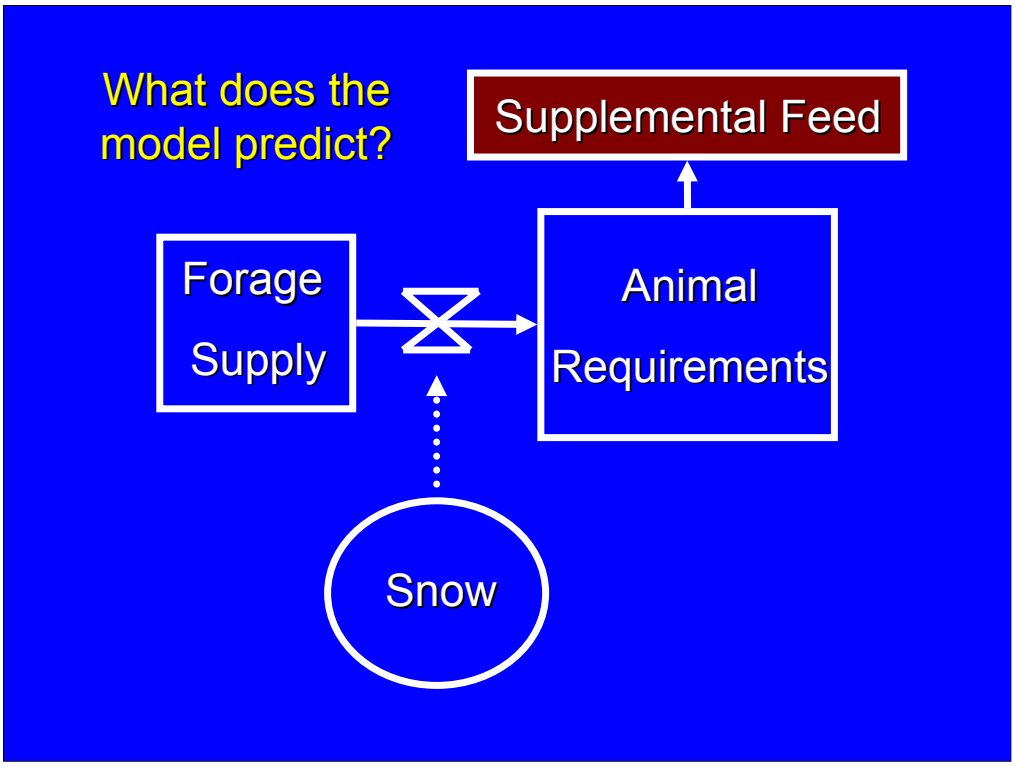
The model predicts the total supply of forage available to ungulates at the beginning of winter and the forage requirements of populations of different size. Most importantly, the model predicts the way that snow accumulation modifies the accessibility of forage.



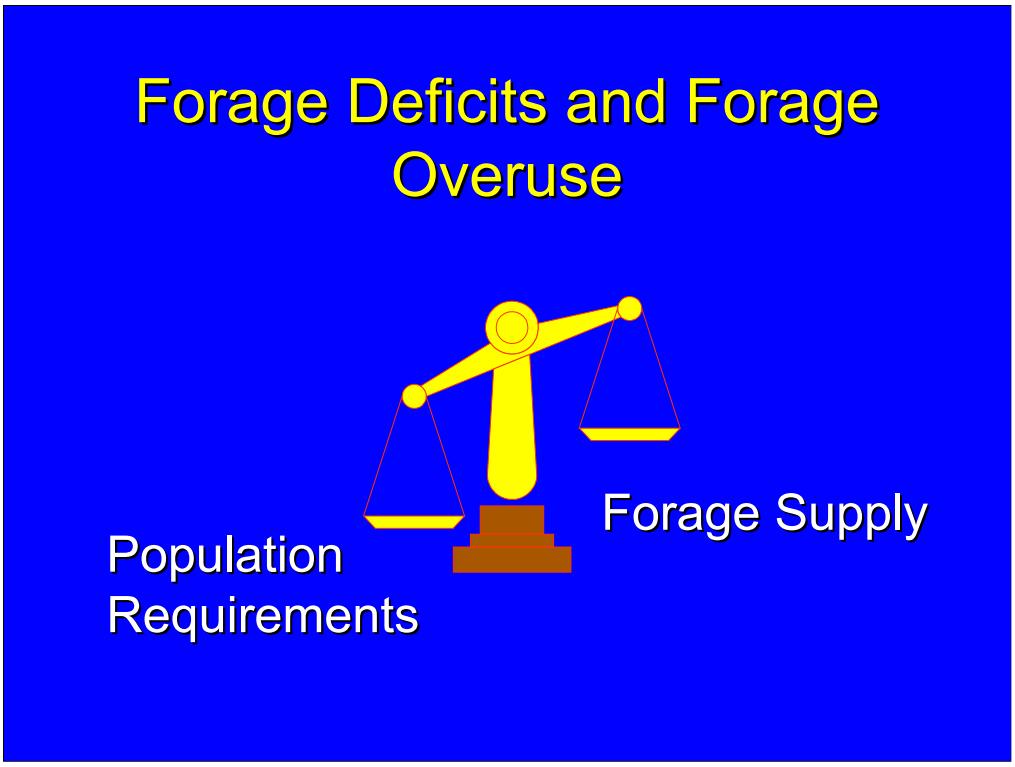
Now, if the amount of accessible forage is less than the amount of forage required by the population, then a forage deficit results. A forage deficit is defined as the difference between the amount of forage *required* by the population and the amount of forage *supplied* by winter habitats. Our model estimates the size of these deficits for different population sizes and different winter conditions.



We also keep track of a quantity we call forage overuse. Forage overuse is defined as the amount of forage consumed by ungulate populations that exceeds 50% of the prewinter standing crop. Forage overuse is intended to indicate consumption of forage that might lead to long term harmful effects on plants an soils.



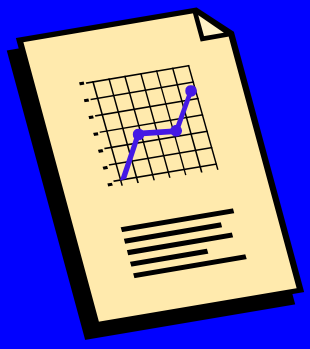
By now you probably have guessed that forage deficits and forage overuse are related to requirements for supplemental feeding. Actually, if we knew these deficits perfectly, we would know precisely how much supplementation would be required to correct the imbalance between forage supply and animal demand.



So, to summarize, the model predicts forage deficits and forage overuse. These two quantities are different ways of looking at the imbalance between forage supply and animal requirements.

A Forage Accounting Model

- What does it predict?
- How does it work?



So, I've covered what is predicted by the model. Now let tell how it works.

Model Steps

- Calculate pre-winter forage supply.
- Estimate effects of snow on forage availability.
- Calculate forage demand.
- Update forage supply to reflect removal.
- Calculate forage deficit, forage overuse.

Here are a summary of the calculations in our model.

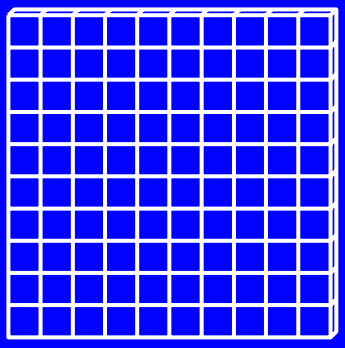
We start by calculating the total standing crop biomass of forage throughout the study area at the beginning of winter.

Then, for each week of the winter, we estimate the effect of snow on forage availability.

We then calculate the amount of forage required by a given, target population of ungulates.

We update the forage supply to reflect consumption, and we assess forage deficits and forage overuse. Let me take a few minutes to tell you about how each of these steps is accomplished.

Pre-winter Forage Supply



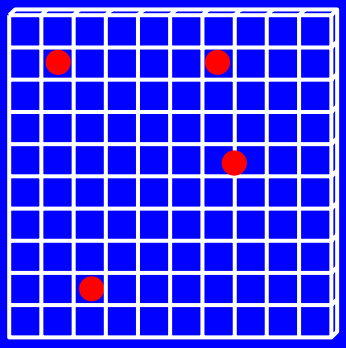
Vegetation Map

For each cell:

Assign biomass based on vegetation type and production data.

We estimate the prewinter supply of forage using a gridded vegetation map. We use field data to assign a standing crop to each cell in the map at the beginning of winter.

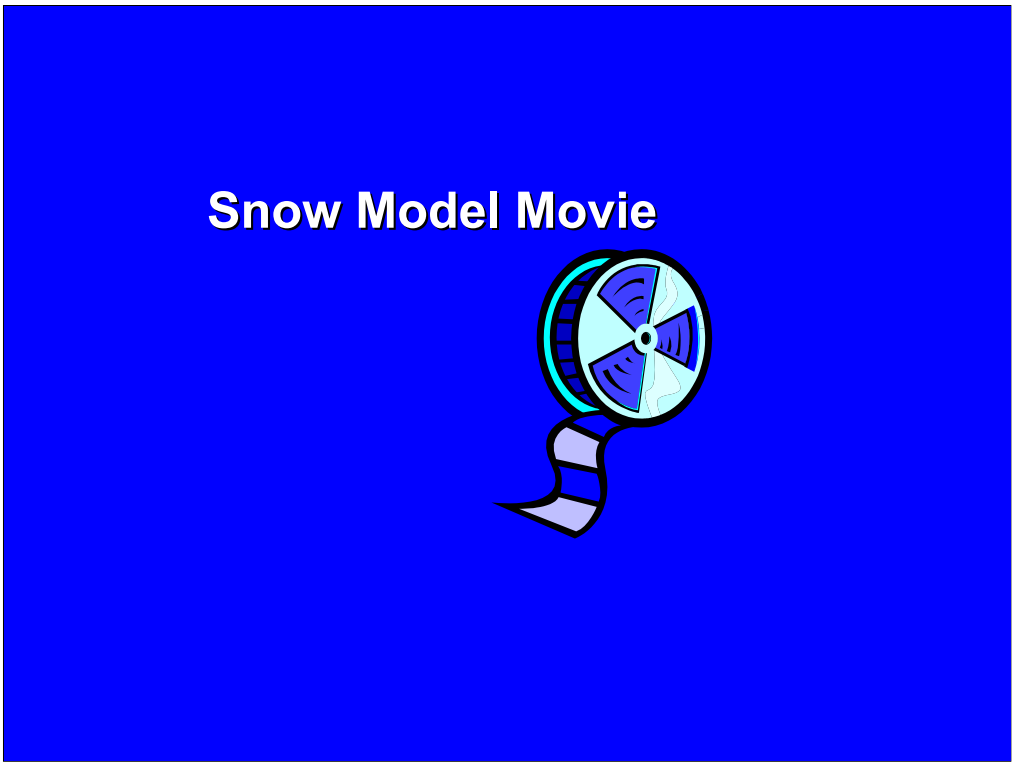
Distribution of Snow



Snow Map

- Spatial interpolation of SWE data.
- Interpolation adjusted by
  - elevation
  - aspect
  - slope
  - vegetation
- Gross Ventre adjusted for snow shadow

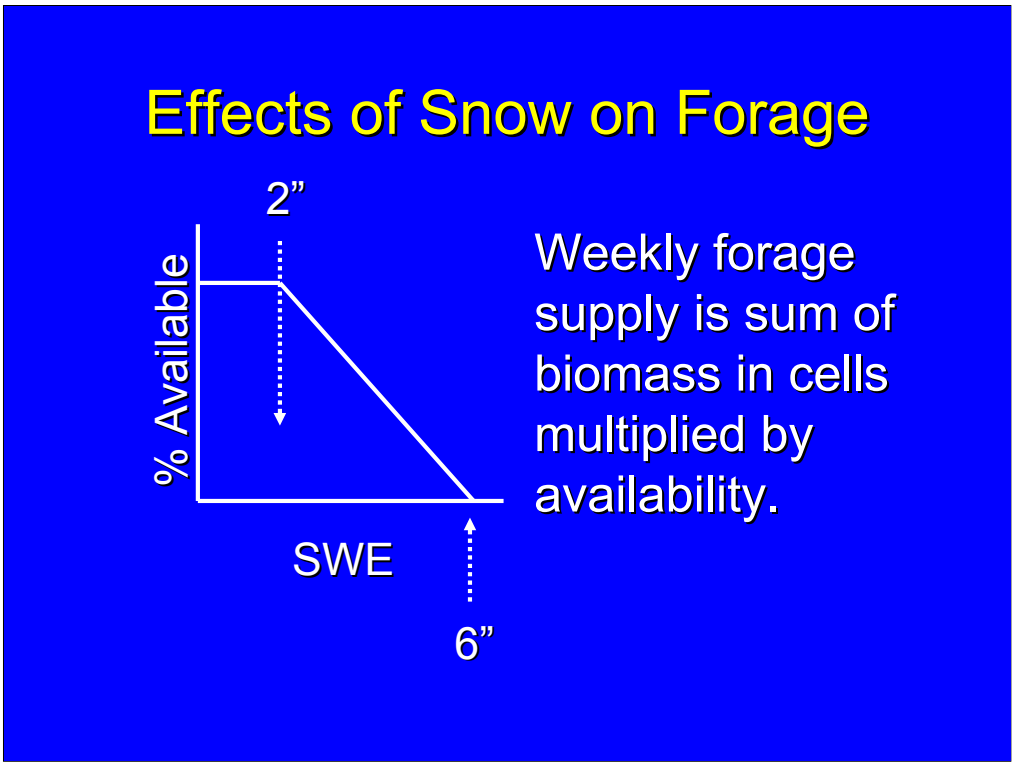
We also used a cell-based map to estimate the spatial distribution of snow for each week during winter. We start with data on Snow Water Equivalents from 65 snow stations and use interpolation to estimate the SWE in cells where we don't have data. The interpolated values are then adjusted for effects of elevation, slope, aspect, and vegetative cover within each map cell. The snow map in the Gros Ventre is also adjusted to reflect a snow shadow effect from the Tetons.



So now what I would like to do is to show you the kinds of predictions the model makes by showing maps of the distribution of snow during a sever winter, 1997.

(the movie can be seen at www.nrel.colostate.edu/projects/teton)

Dark blue indicates areas where forage is unavailable. Light green shows areas with partial availability, and dark green indicates 100% forage availability.



The model adjusts the availability of forage in each cell in the map using this relationship. When SWE in a map cell is less than or equal to 2 inches, we assume that 100% of the forage in that cell is available. When SWE in a map cell exceeds 2", we assume that availability declines in proportion to SWE until no forage is available at SWE levels exceeding 6".

Calculate Weekly Forage Demand

- Set target population for elk
- Calculate average body mass based on sex and age data.
- Estimate intake as 2% of body mass.
- Total demand = target population * intake rate

To estimate the total weekly demand for forage, we start with a target density for the elk population. Remember this is a decision variable that we will adjust in model experiments.

We then calculate an average body mass weighted by the sex and age composition of the population.

That weighted average body mass is used to calculate total weekly intake for an individual.

And the demands of the population are estimated as the target population size multiplied by the individual intake rate.

Model Results

- Population size and feeding requirements?
- Does feeding compensate for habitat loss?
- Impacts of continued increases in bison population?
- Consequences of livestock grazing?

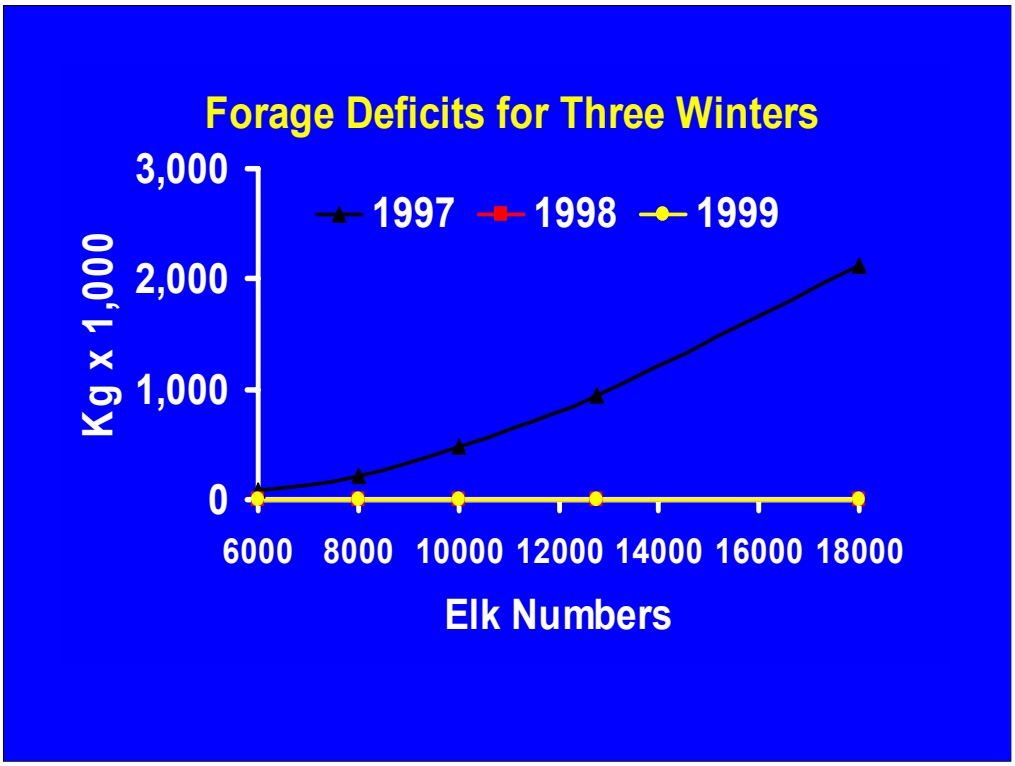
So that's how the model works. Its really pretty simple. Now I want to talk about what we can learn from the model.

Model Experiment 1

- Question: Could supplemental feeding be reduced or eliminated?
- Experiment: Vary population size and observe forage overuse and forage deficits.

One of the most important questions confronting managers in the Jackson area is whether or not supplemental feeding could be reduced or eliminated if elk densities were reduced.

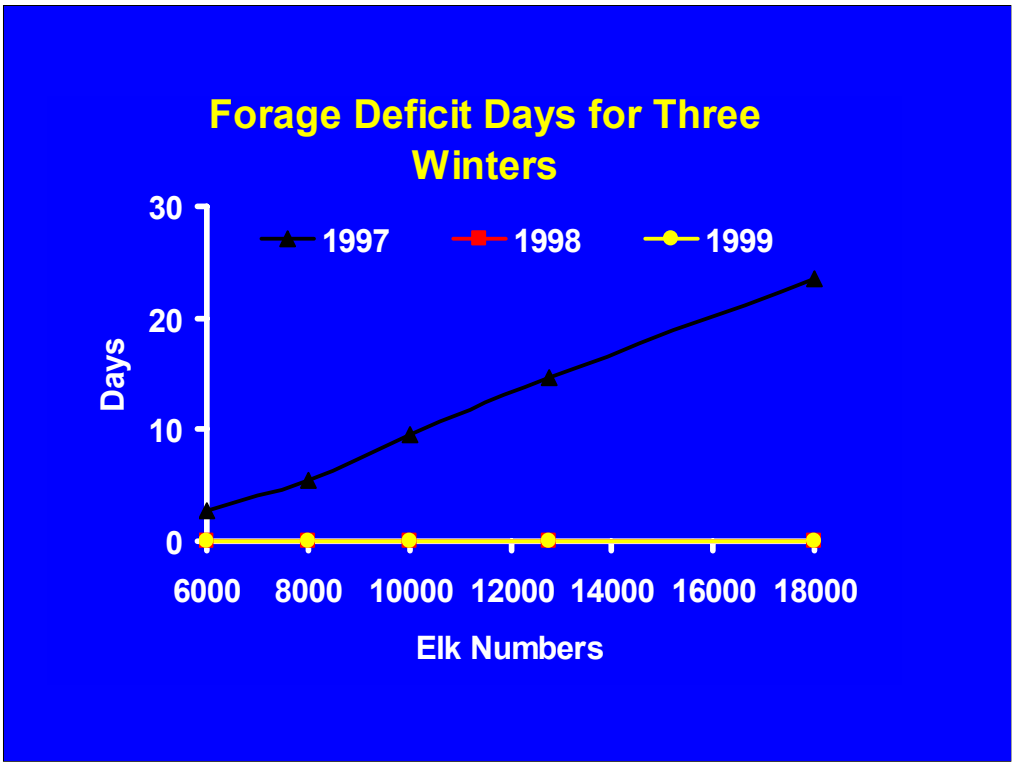
To get at that question we varied the target population size of the elk population and examined model predictions for forage deficits and forage overuse.



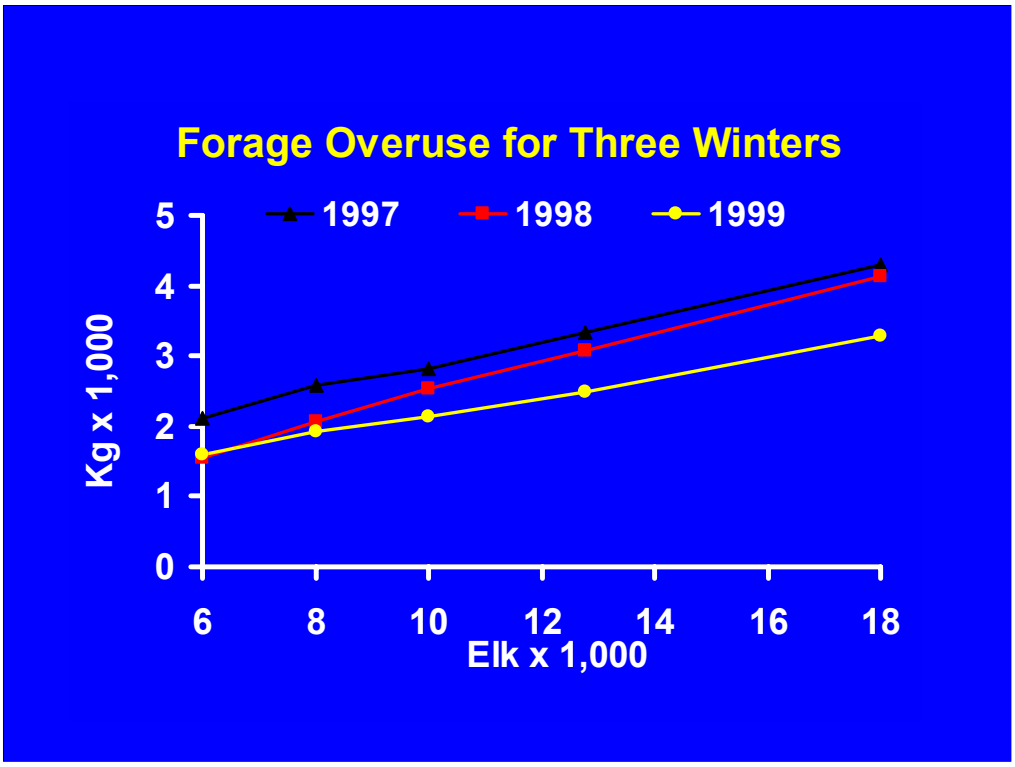
Here are some results. On the x-axis we have different population objectives for elk ranging from 6000 to 18000 animals. On the Y axis we have the magnitude of the forage deficit. There are 3 predictions, a severe winter (1997), a moderately severe winter (1998), and a average winter (1999).

There are two important results. First, the model predicts that forage supplies in winter habitats are able to meet or exceed the forage requirements of the current population of native ungulates during average and moderately severe winters (i.e. no deficits).

Second, during severe winters some supplemental feeding would be required to correct forage imbalances for all population levels. As population size increases, the magnitude of the forage deficit increases exponentially.

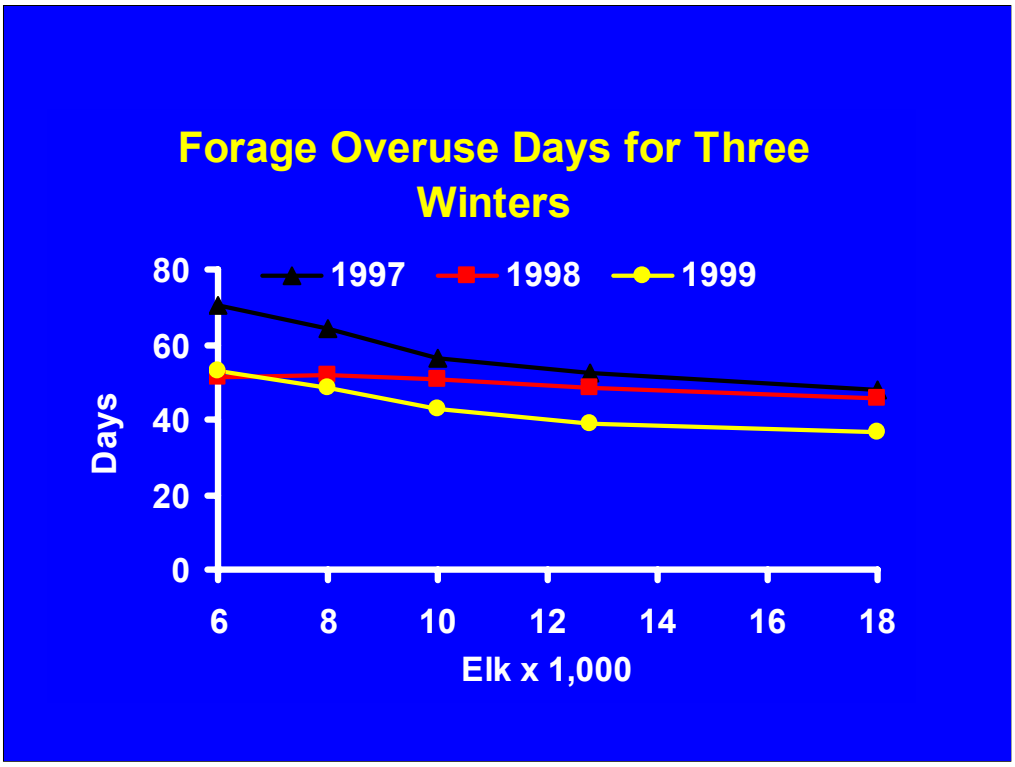


We can translate those deficits directly into the number of days a population of a given size would have to be fed to offset the deficit. Our model predicts that even during severe winters, feeding the current population for 18 days would bring forage supplies into balance with forage requirements. Again, there are no forage deficits in 1998 and 1999.

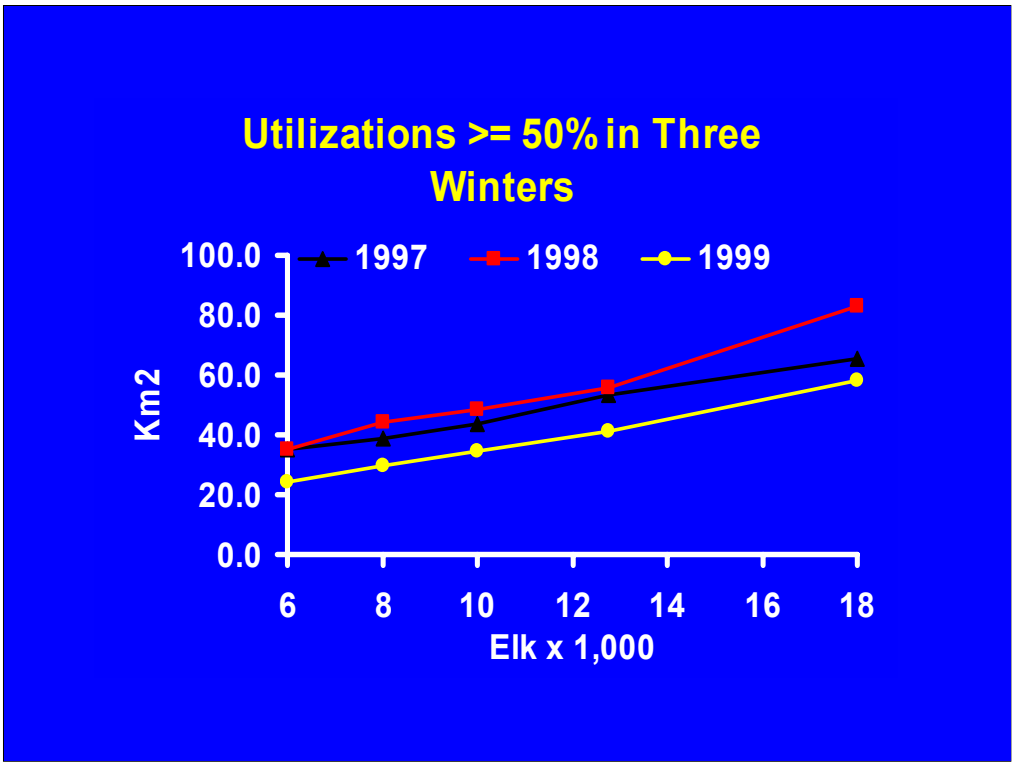


This graph shows model predictions of forage overuse on the y axis and the target elk population size on the x axis.

We estimated that some forage overuse would occur at all population sizes. We also found that the magnitude of overuse was directly proportionate to the number of elk in the population. As you would expect, overuse was higher during severe winters than in average winters.



Eliminating forage overuse would require substantially more supplemental feeding than eliminating forage deficits. In this case feeding would have to be provided for all population sizes and for all winter conditions. Note that while the duration of feeding required to eliminate forage overuse is greatest for the smallest populations, the amount of feed provided increases in direct proportion to the size of the population.



In this graph we show the total area of landscape were forage utilization exceeds 50% on the y axis and elk population size on the x-axis. The point here is that there will be areas of the landscape that are intensely utilized regardless of population size and winter severity.

Model Experiment 2

- Question: Does supplemental feeding compensate for forage lost to development in Jackson?
- Experiment: Vary target population size and add forage supplies south of wildlife fence.

The second question we asked has to do the fundamental justification for supplemental feeding in the Jackson region. Feeding is usually justified in terms of the need to compensate for forage that is lost due to development of winter range in Jackson.

To get at this question, we estimated the amount of forage that could be produced in areas that are now developed. We added this forage to the forage supply and looked at forage deficits for populations of different size.

Interpretation

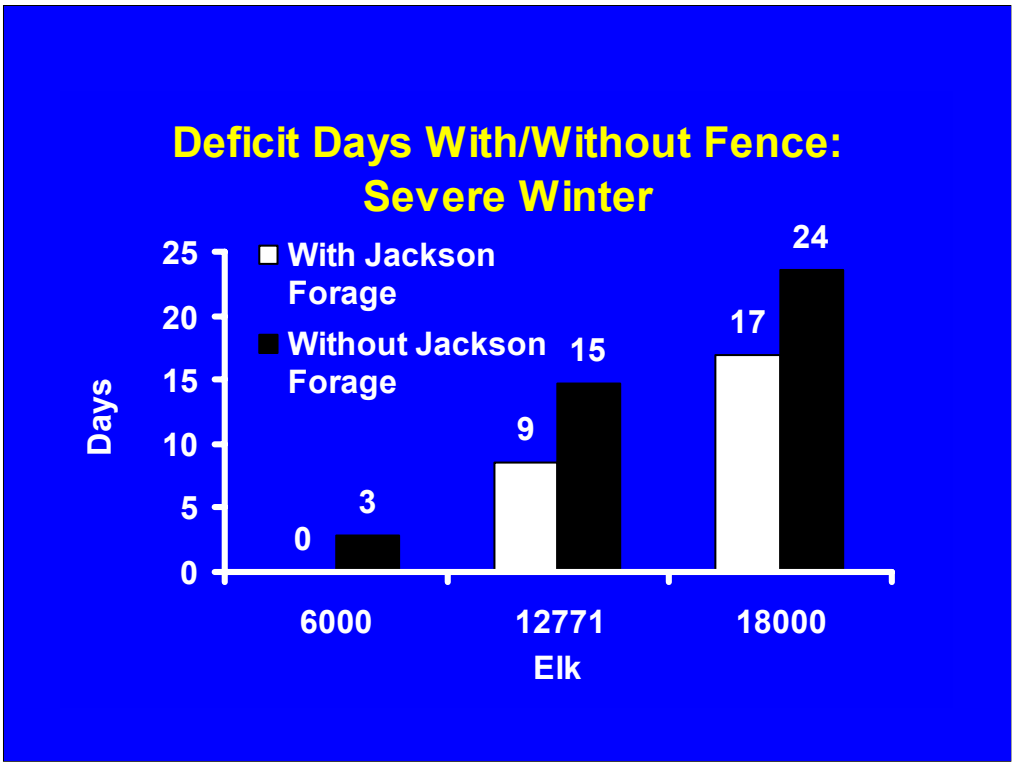
- Forage deficit removed after adding Jackson: Feeding target population compensates for habitat lost.
- Forage deficit remains after adding Jackson: Feeding target population *overcompensates* for habitat lost.

The results from this model experiment can be interpreted as follows.

If adding the forage lost to development in Jackson eliminates the deficit for a given target population, then feeding compensates for habitat loss for a population of that size.

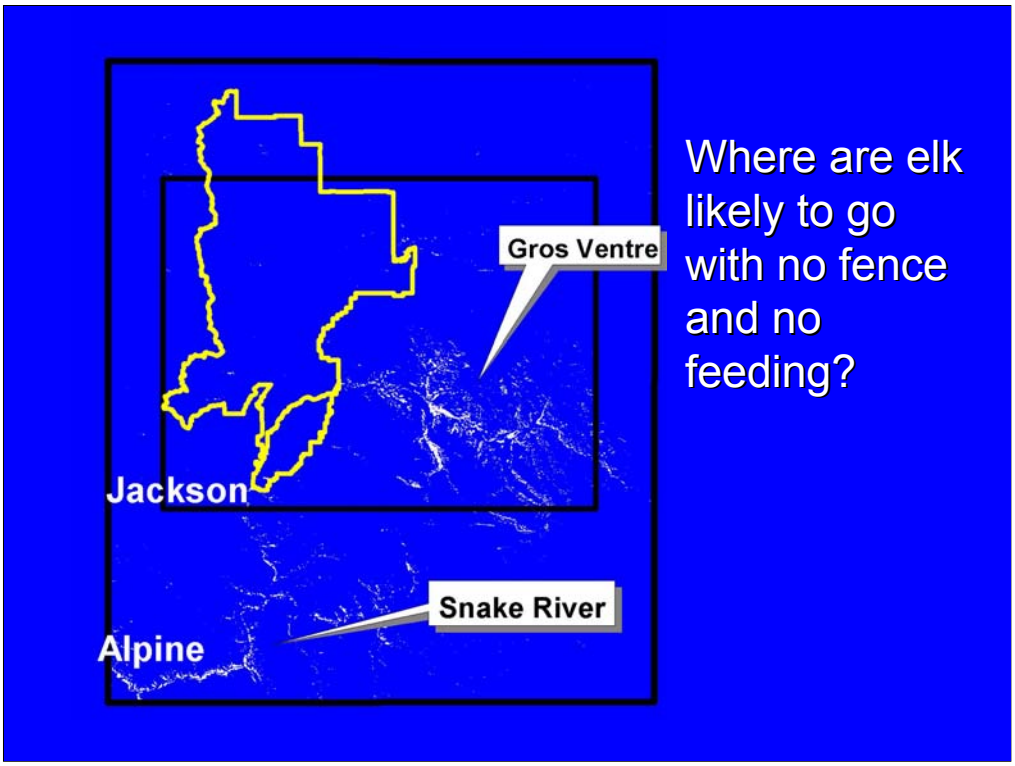
If the forage deficit is not eliminated for a given population size, then supplemental feeding is providing more forage than was lost to development, and feeding overcompensates for the effects of development.

This is to say that there are more animals being supported by feeding than probably could be supported if Jackson had never developed.



On the Y axis is the number of days that a target population would need to be fed to eliminate forage deficits during sever winters with and without forage in Jackson

Model results suggest that supplemental feeding would compensate for development if the elk population numbered about 6000 animals.. At population sizes greater than 6000, it appears that supplemental feeding overcompensates for supplemental feeding.

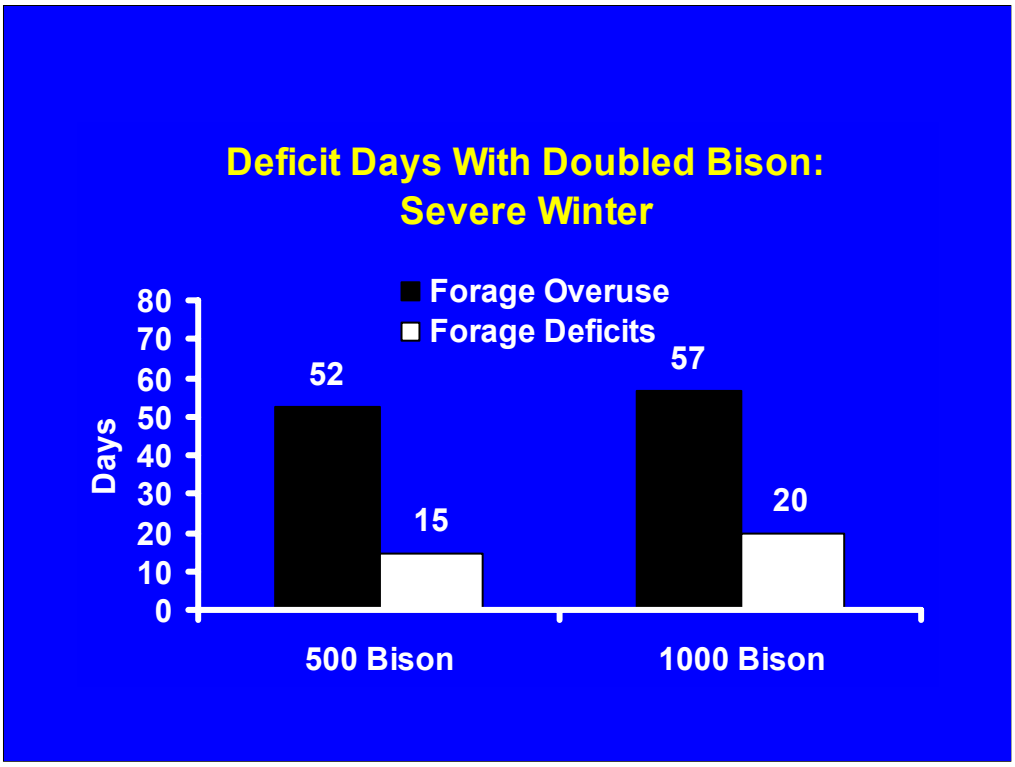


We also asked the question, where are ungulates likely to concentrate if feeding is eliminated? What we are showing in white are areas of the landscape with <5" SWE on March 8, 1997, a severe winter. The two areas of concentration are the Gros Ventre and the Snake River valley south to Alpine.

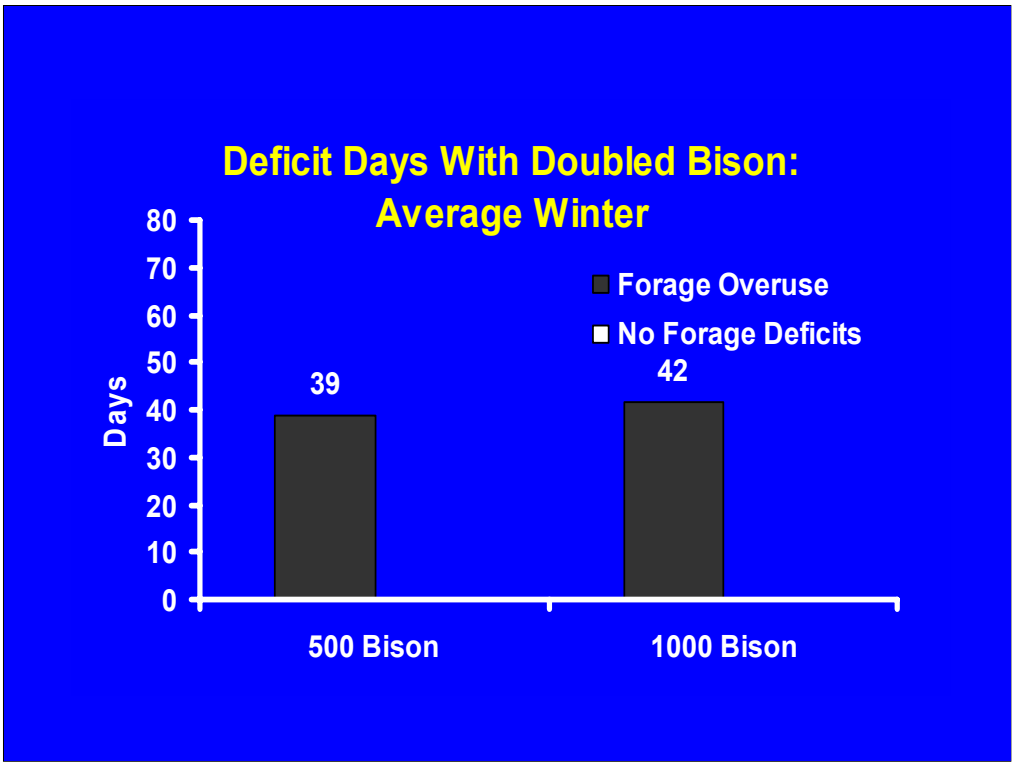
Model Experiment 3

- Question: Effect of doubling bison population size?
- Experiment: Recalculate forage deficits based on 2 x 1999 population estimates for bison. Hold elk population constant.

In our third experiment we examined the potential consequences of doubling the bison population size. We recalculated forage deficits and forage overuse assuming that the bison population size was double 1999 levels. Population numbers for all other ungulates were held constant in these simulations.



Increases in the bison population could substantial magnify forage deficits and forage overuse. Increasing bison numbers by 500 animals increased forage deficits during a severe winter by 1/3 and increased forage overused by 10%.



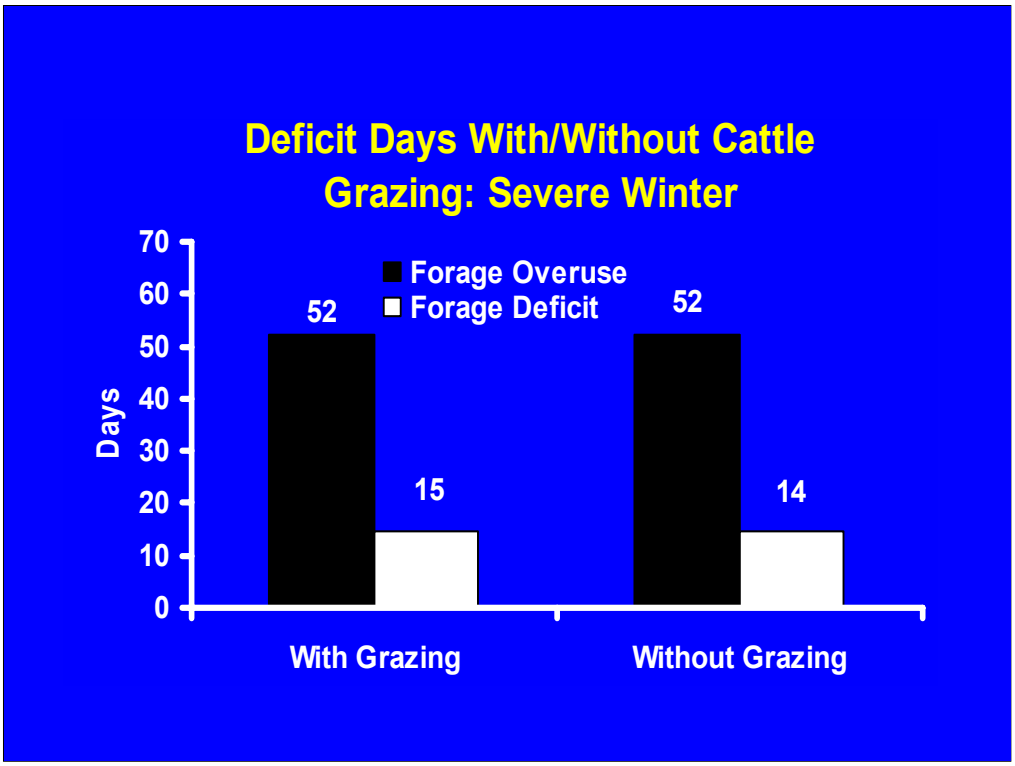
During an average winter, there were no forage deficits, but doubling the bison population size amplified forage overuse by about 8%.

Model Experiment 4

- Question: Does livestock grazing meaningfully reduce forage supplies for wintering native ungulates?
- Experiment: Recalculate forage deficits with and without livestock grazing.

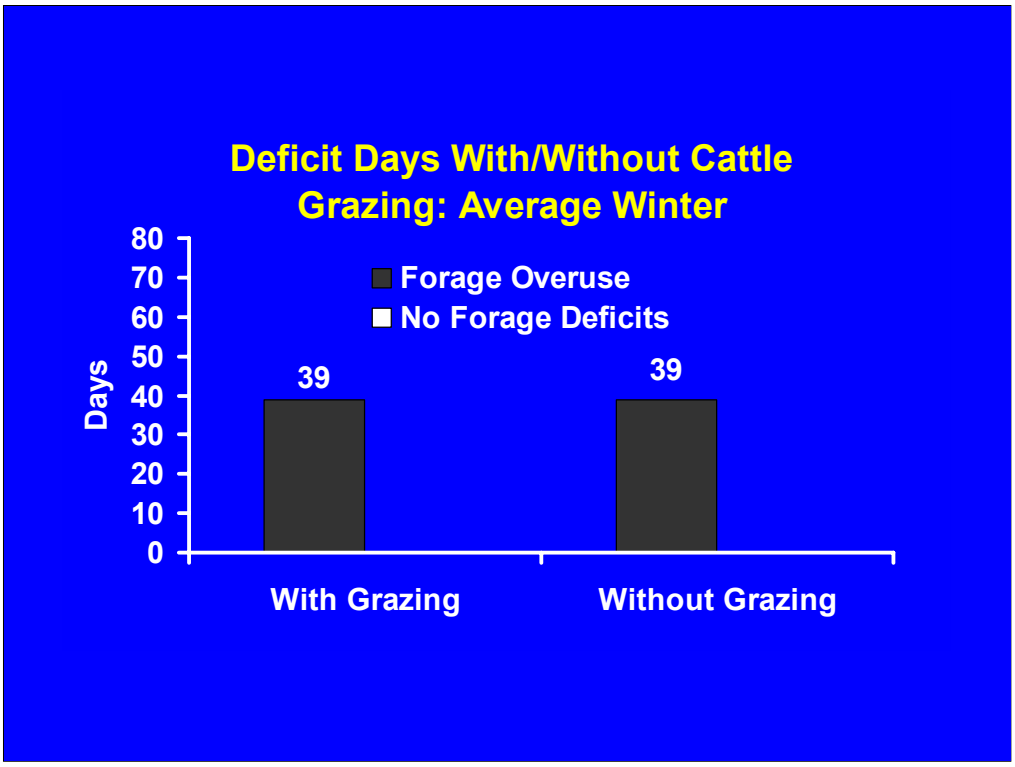
Our final experiment looked at impacts of livestock grazing during summer on forage supplies for native ungulates during winter. We wanted to know if eliminating livestock grazing on public land would meaningfully influence the balance between forage supplies and wildlife requirements.

To get at this question, we recalculated the prewinter forage supplies assuming no removal by livestock during summer.



Model results suggest that during a severe winter, livestock grazing has virtually no impact on forage overuse or forage deficits. On the Y axis we have the number of days that a population of 12,800 animals would have to be fed to eliminate forage deficits and overuse. There were only minor differences between the model runs that included effects of livestock grazing on prewinter forage supplies and those that didn't.

Theses results are easily explained. Most of the forage consumed by livestock during summer comes from areas of the landscape where snow accumulation precludes use by native ungulates during winter. It follows that even when large amounts of forage are consumed by livestock, this consumption does not reduce forage supplies where they are needed by wintering ungulates.

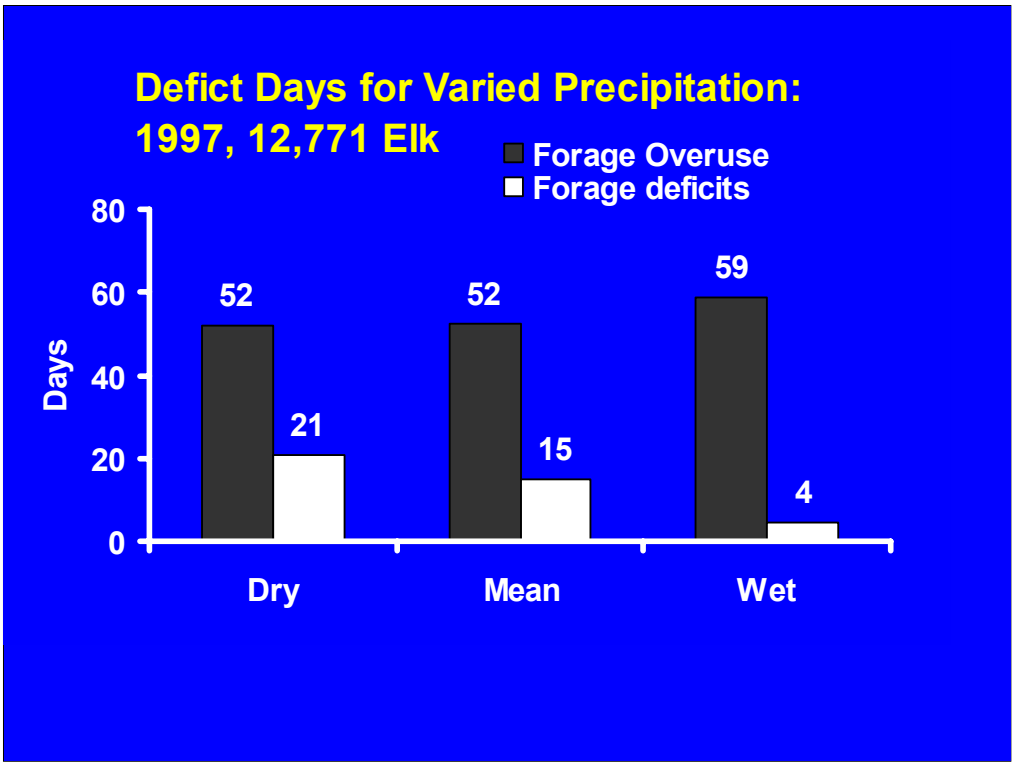


We saw similar results for an average winter. Remember during average winters there was no forage deficit. Removing cattle grazing did not exert any effect on forage overuse.

Model Experiment 5

How do these results depend on variation in pre-winter standing crop of forage?

The previous model experiments used an “average” pre-winter standing crop based on an average amount of precipitation in the previous spring and summer. How will a wet or dry year affect the results?



Vegetation samples taken during dry and wet years suggest that a dry year causes pre-winter standing crop to be 85% of an average year and a wet year causes pre-winter standing crop to be 150% of average.

The above model experiment estimates that drought conditions (85% of average) cause a 33% increase in forage deficits while wet conditions (150% of average) cause a 66% decrease in forage deficits.

Forage overuse is not significantly affected by precipitation extremes

Findings

- Eliminating forage deficits in severe winters would require drastic population reductions.
- During average winters, natural habitats are capable of supporting unsupplemented populations.

Now let me summarize our findings.

Our model results suggest that supplemental feeding would be required to eliminate forage deficits during severe winters unless the current population were to be drastically reduced. If the elk population were reduced to about 6000 animals, we project that forage deficits would be eliminated even during severe winters.

During average winters, it appears that natural forage natural winter habitats could support populations at least as large as the current population.

Findings

- Forage overuse is proportionate to elk population size. Some areas will be heavily grazed regardless of population size.
- Supplemental feeding appears to overcompensate for forage lost to development in Jackson.

The extent of forage overuse is directly proportionate to elk population size. This means that some areas of the landscape will be heavily grazed, regardless of population size.

It appears that supplemental feeding of the current elk population substantially overcompensates for forage lost to development in and around the town of Jackson. The assumption that supplemental feeding compensates for habitat loss is appropriate only for populations of about 6000 elk during severe winters.

Findings

- Doubling bison population numbers will have substantial impacts on forage deficits.
- Reducing livestock grazing will have minor effects on forage deficits.

We project that continued increases in bison abundance could have substantial impacts on forage deficits and forage overuse. In particular, an increase of 500 bison would result in a 30% increase in forage deficits for all ungulates during severe winters.

Finally, it appears that livestock grazing has virtually no effect on forage deficits for native ungulates during severe or average winters.

Work in Progress

- Examine consequences of forage deficits for animal condition.
- Examine consequences of forage overuse for ecosystem sustainability.

There are a couple of questions remaining that are very important for interpreting our results. First, we need to understand how forage deficits of different magnitudes will affect the conditions of individual animals and the mortality rate of populations. We are building an individual-based, energy balance model to address this question.

Second, we need to understand how forage overuse might affect soil fertility and long term plant production. We are now working with the Century model to understand how different levels of use affect sustainability of net primary production.