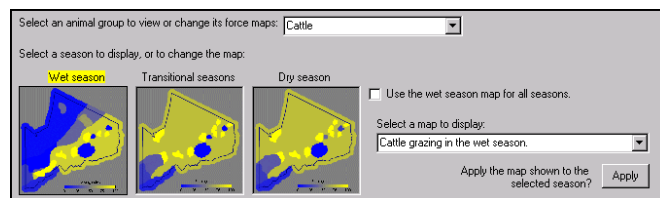


## Experiments - Allowing Livestock in the Craters

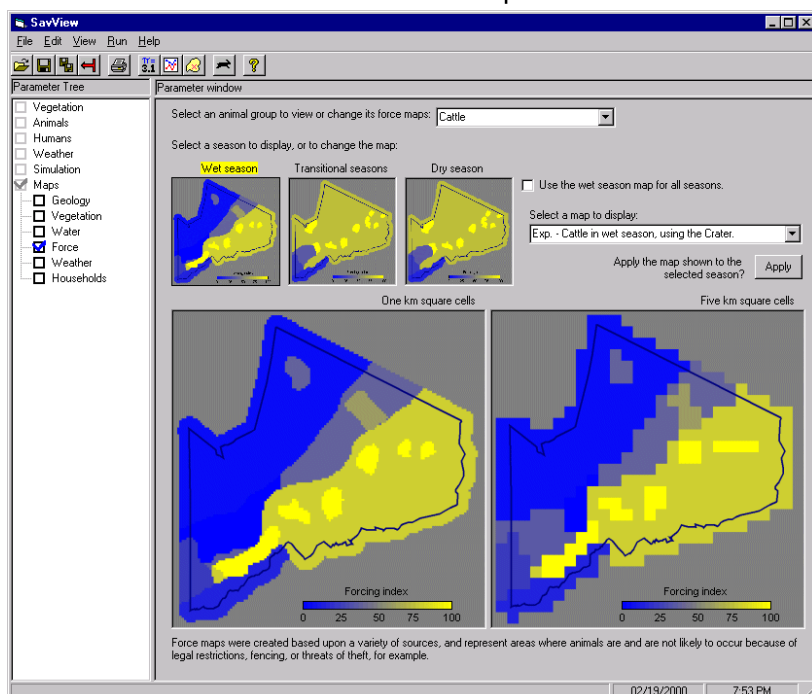
One of the most useful things about the nature of Savanna is its ability to include spatial relationships in its modeling. Examples are GIS maps that describe topography, vegetation, water availability, and things affecting the distribution of animals. Once the control model is created, these spatial data may be adjusted to simulate the effects of proposed management decisions. The breadth of questions that may be addressed is diverse.

Force maps incorporated into Savanna describe restrictions upon species that are not directly tied to ecological relationships. In Ngorongoro Conservation Area, for example, Maasai herders may move their livestock into the craters to reach water, but they may not stay to graze. We may judge the relative importance of this restriction using Savanna.

**Default, with livestock excluded from the craters**



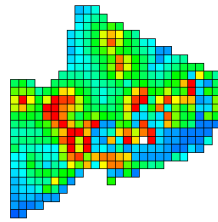
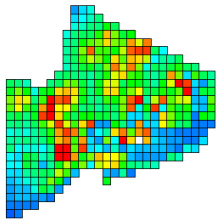
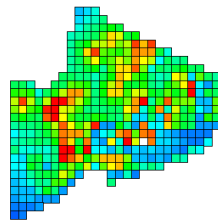
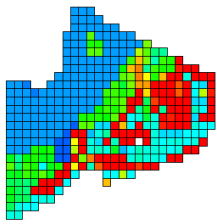
**Livestock allowed in craters**



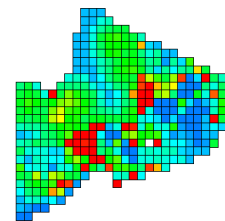
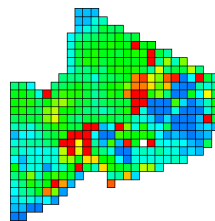
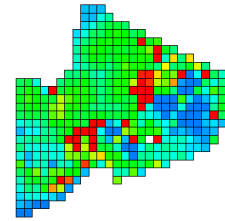
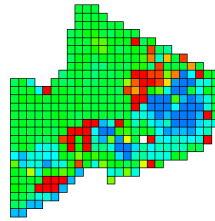


## Experiments - Allowing Livestock in Craters (continued)

### Cattle

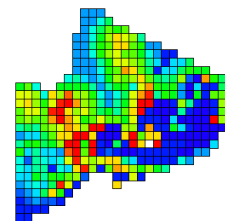
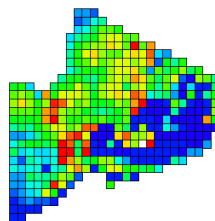
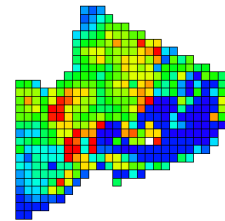
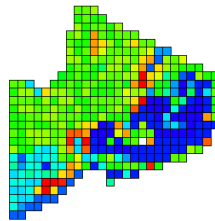


### Goats



*Cattle, goat, and sheep distributions, each for a typical April to July*

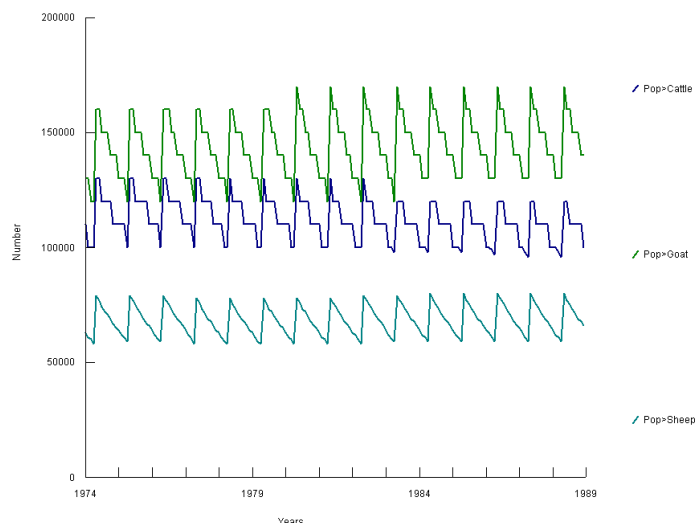
### Sheep



When livestock are allowed to use the craters, cattle and sheep occupy Ngorongoro Crater fairly densely. However, better habitat elsewhere causes goats to avoid the crater, for the most part.

### *Livestock populations*

Little change occurs in livestock population, even declining due to disease.



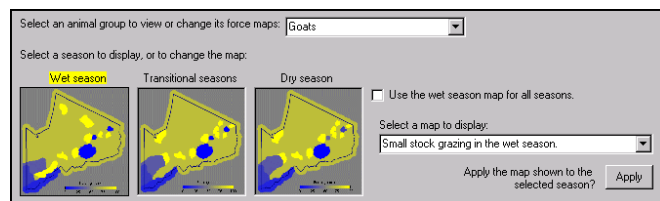


## Experiments - Removing the Threat of Livestock Theft

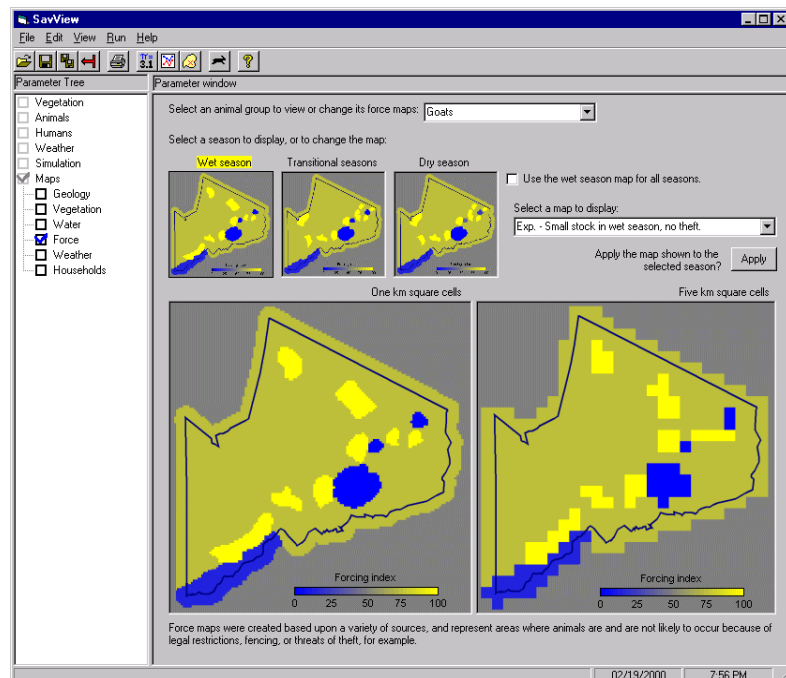
In Ngorongoro Conservation Area, Maasai herders tend to avoid using the southern part of the area, south of Kakesio, because of a high likelihood of animals being rustled. This was incorporated in Savanna by modifying the force maps used for livestock. In force maps, values between 0 and 100 may be used to represent how likely animals are to occur in a grid cell (0 being absent, 100 being no restrictions). Because herders may use the southern part of the area, but are just not as likely to, in the force maps we assigned low values to these southern areas, between 25 and 40.

Using Savanna and SavView, we can estimate the relative benefits of allowing livestock to graze in the southern part of the area, and balance that with the costs of improved security. In SavView, we

**Default, with livestock somewhat restricted from using the southern areas**



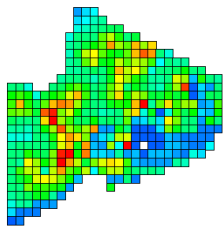
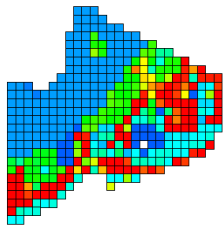
**Livestock not limited from using the southern areas**



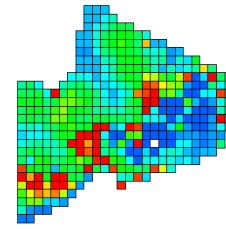
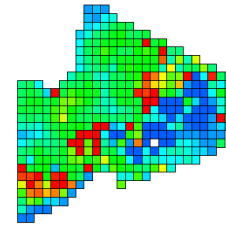
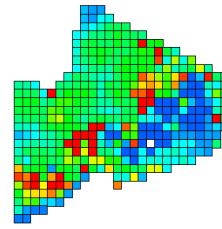
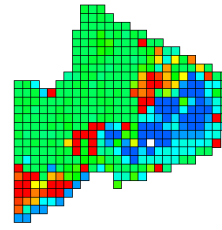
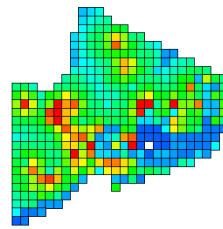
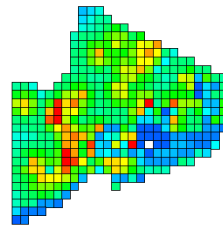


## Experiments - Removing the Threat of Theft (continued)

### Cattle

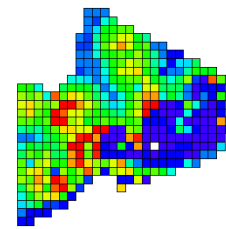
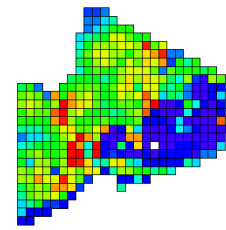
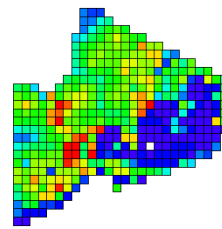
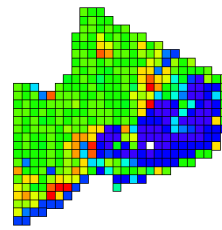


### Goats



*Cattle, goat, and sheep distributions, each for a typical April to July*

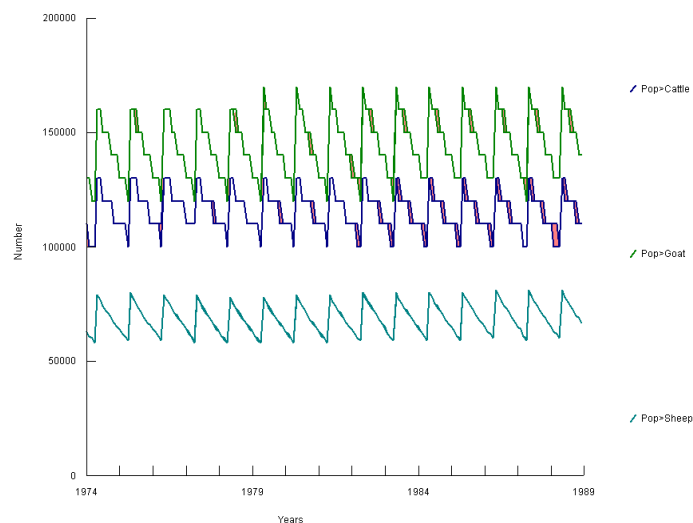
### Sheep



Each of the livestock groups were distributed in the southern portion of NCA, when the threat of theft was removed. The habitat was particularly favorable to goats.

### *Livestock populations*

Little change occurs in livestock population, but condition indices to increase somewhat.





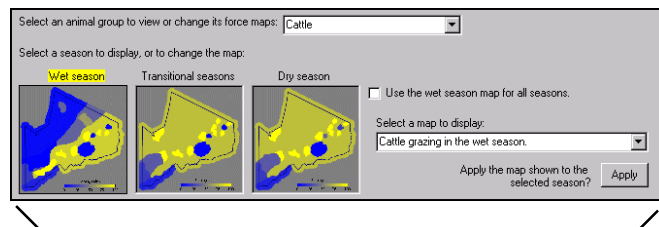


## Experiments - Removed Threat of MCF

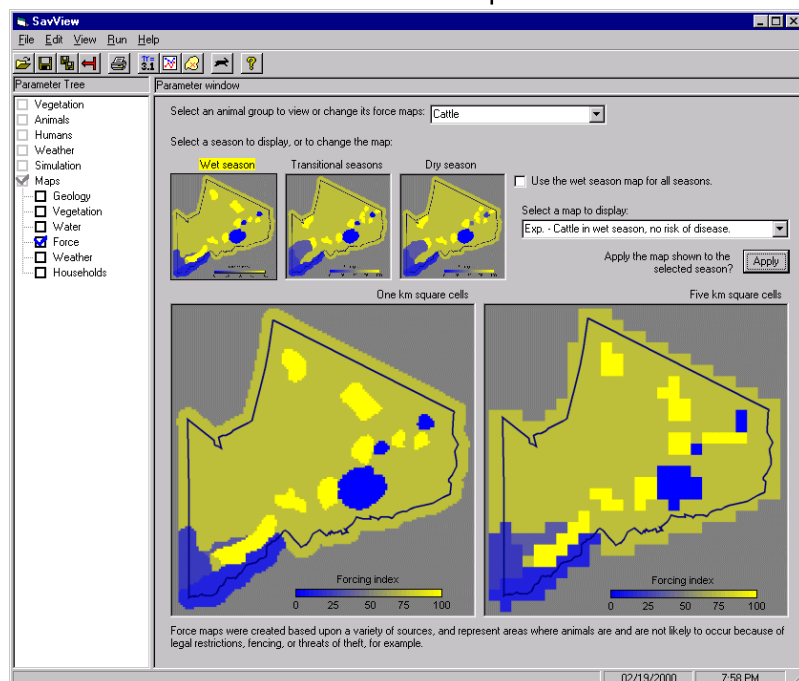
Wildebeest move into Ngorongoro in the early wet season and begin to calve. Infected wildebeest calves secrete in their mucus the pathogen that causes malignant catarrhal fever (MCF) in adult cattle. When infected with MCF, almost all cattle will die. Maasai herders are well aware of the risks posed by grazing their cattle in areas used by migratory wildebeest, and avoid the areas during the wildebeest calving season. The importance of this restriction upon their grazing has changed in recent decades as well, with a large increase in the numbers of wildebeest.

What would be the effects of allowing herders to use those areas now avoided because of MCF? Savanna can suggest answers to such questions. In SavView, go to the “Parameters” window and to “Maps” and “Force”, then select cattle from the list. Ensuring that

**Default, with herders not grazing cattle on the plains in the wet season**



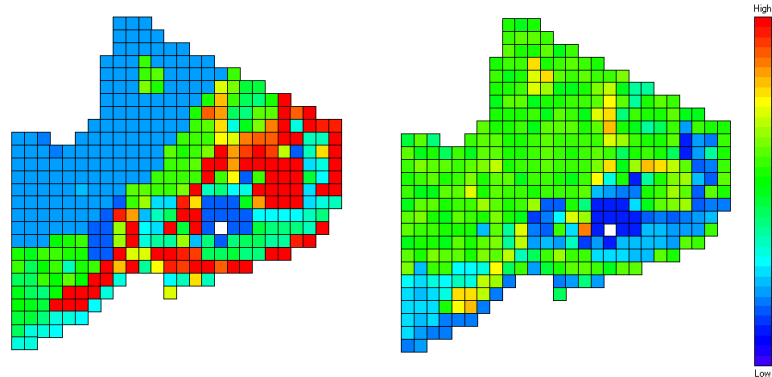
**Cattle able to graze on the plains in the wet season.**





## Experiments - Removed Threat of MCF (continued)

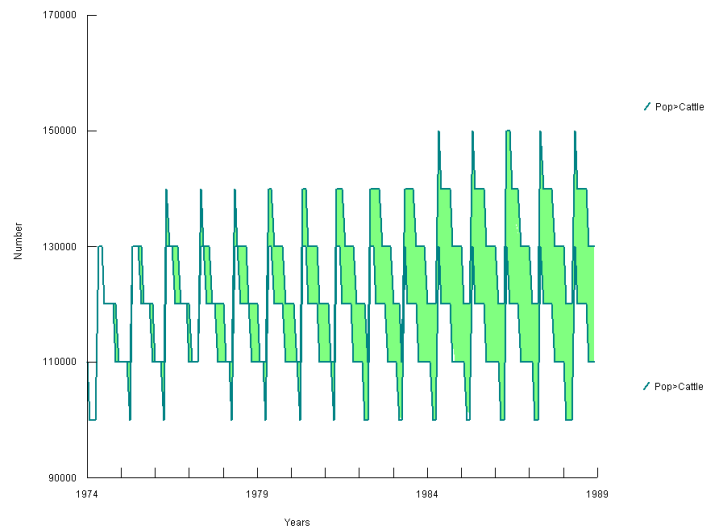
*Cattle distributions under the control model (left) and without risk of MCF (right)*



Cattle are distributed across Ngorongoro Conservation Area during the wet season, if the restriction due to MCF is removed.

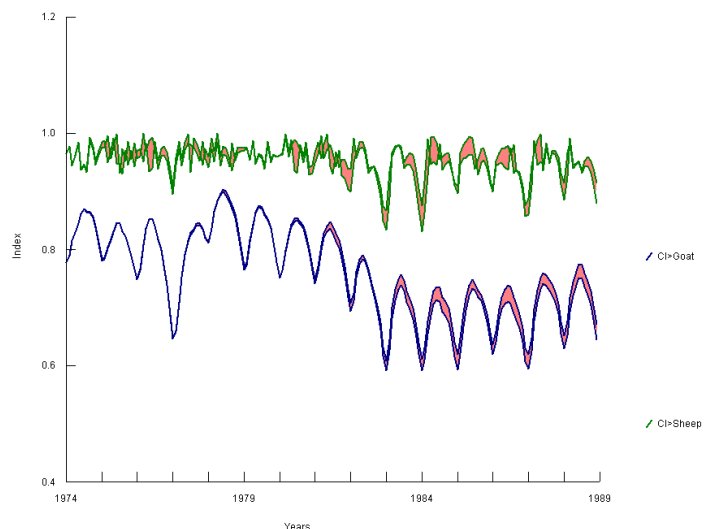
### *Livestock populations*

The increased grazing area allows the cattle population to expand in spite of the population being limited somewhat by other diseases such as ECF.



*Goat and sheep condition indices under the control and experiment.*

Small stock populations remain stable, but their condition indices do decline slightly.



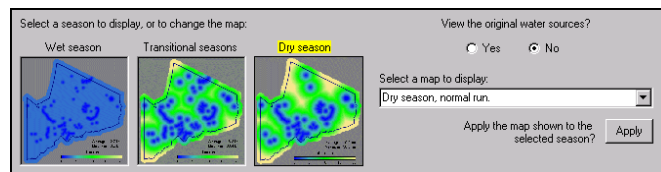


## Experiments - Adding or Restoring Water Sources

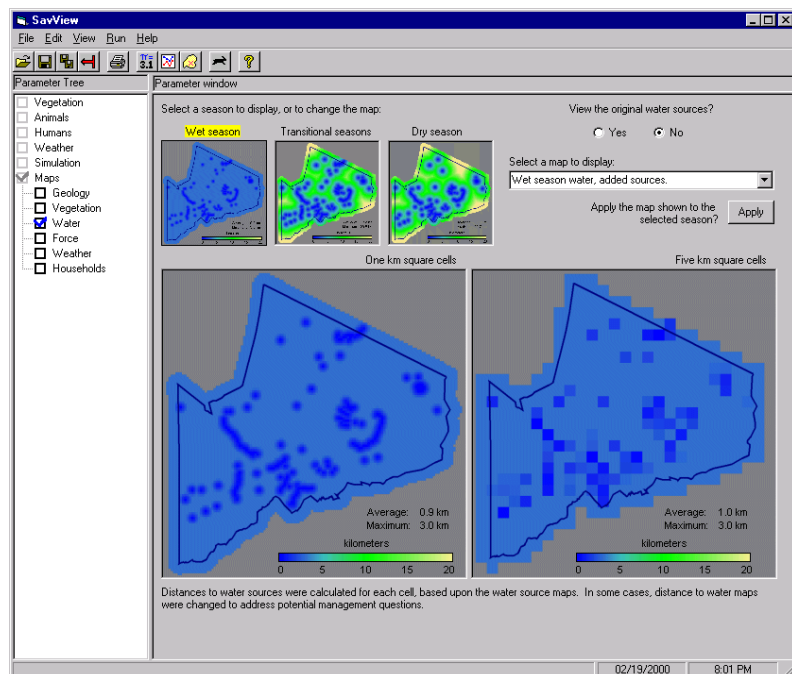
As a semi-arid area, water availability in Ngorongoro Conservation Area is important in determining the distribution of wildlife and livestock. Areas where water is limited or controlled may have forage that can support livestock but will go uneaten. Efforts to improve range in semi-arid areas often entail adding water sources, increasing the areas where grazing may occur or reducing travel times to reach water.

Savanna uses distance to water maps in its modeling of livestock and wildlife distributions. The cells in these maps simply contain the distance, in meters from the cell to the nearest water source. We can address management questions about water sources simply by modifying the distance to water maps.

**Default, with the typical distance to water and water sources**

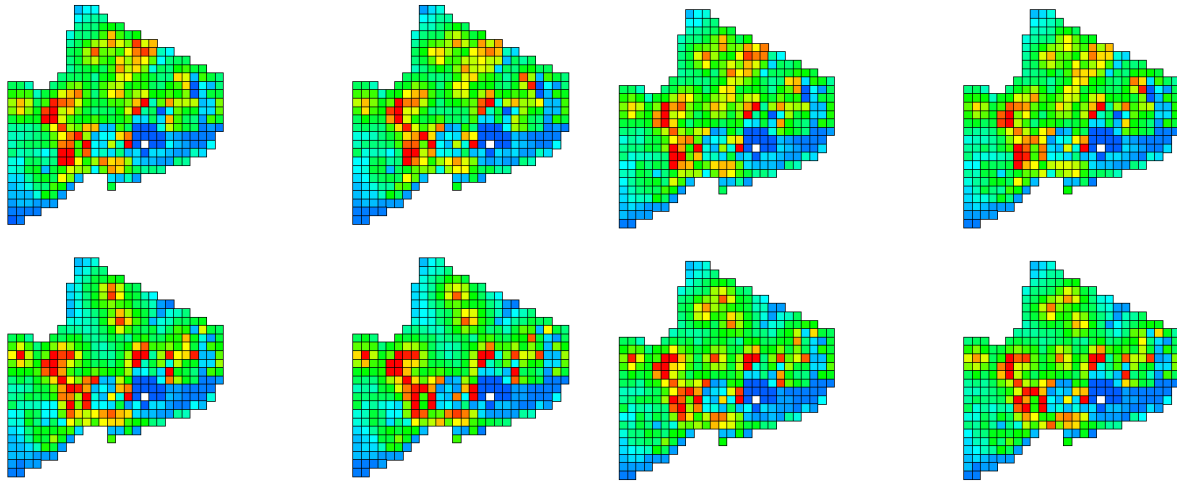


**Additional water sources and reduced distances to water**



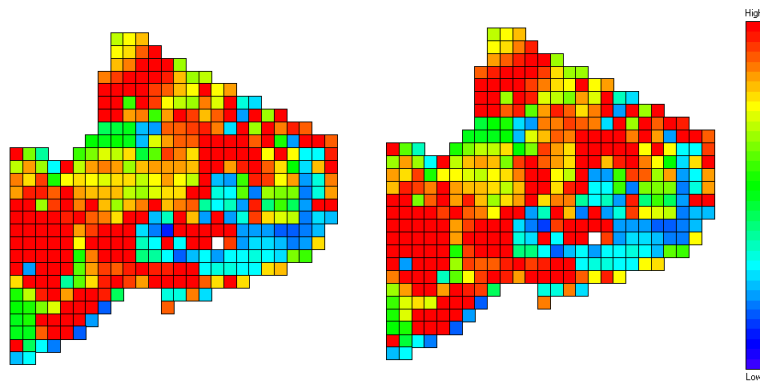


## Experiments - Restoring Water Sources (continued)



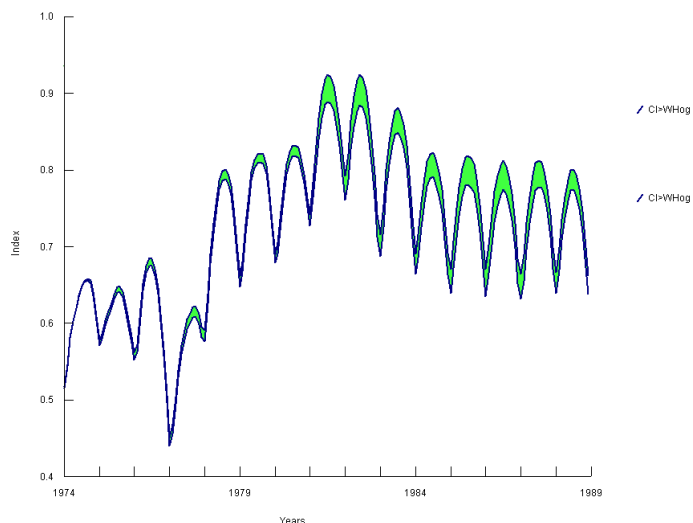
*Cattle distributions in May through August for the Control model (left) and with water added (right)*

*Accumulated offtake for the Control model (left) and with water sources added (right)*



In general, added water sources distributed foraging more evenly across the landscape. Note the increased offtake in the center of the map on the right, for example.

*Warthog condition indices in the Control (lower lines) and with water added (upper lines)*





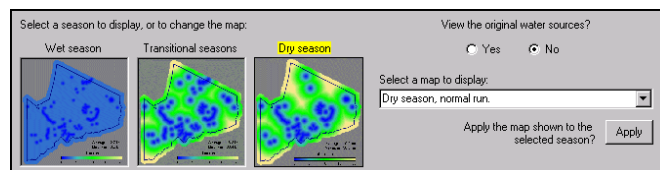


## Experiments - Dedicating Water Sources to Lodges

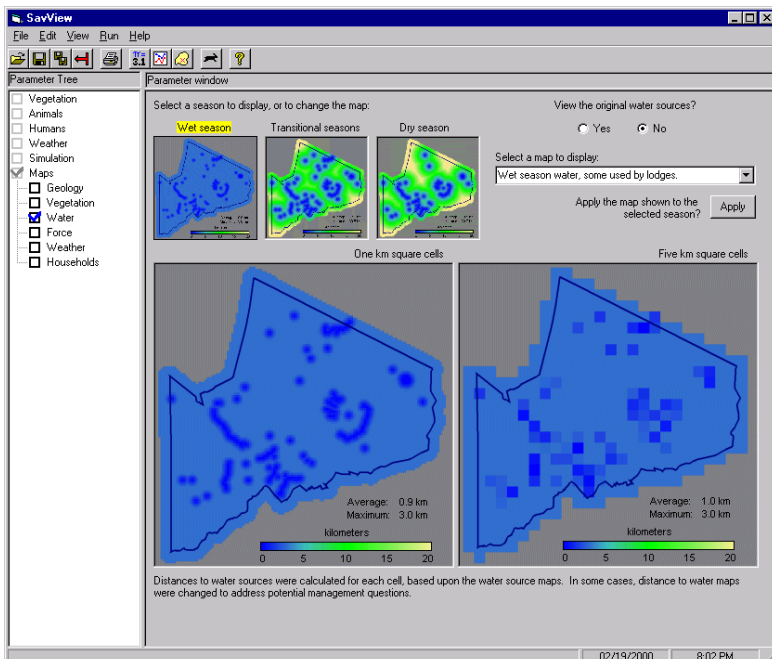
As mentioned, water is important to Maasai and their livestock, as well as wildlife. A contentious issue in Ngorongoro Conservation Area is the use of water to support tourist visits, at the lodges that sit atop Ngorongoro Crater rim. A tool is needed that allows land managers to investigate potential changes to the ecosystem when new lodges are planned, and water diverted.

With its use of distance to water maps, Savanna serves as a tool to address these questions. Distance to water maps may be modified to show reduced water availability. In the experiment, we removed water sources that were within 1 km of lodges. This reduced the number of water sources relatively little, only affecting the area around Ngorongoro Crater.

**Default, with the typical distance to water and water sources**



**Water sources within one kilometer of lodges were removed**

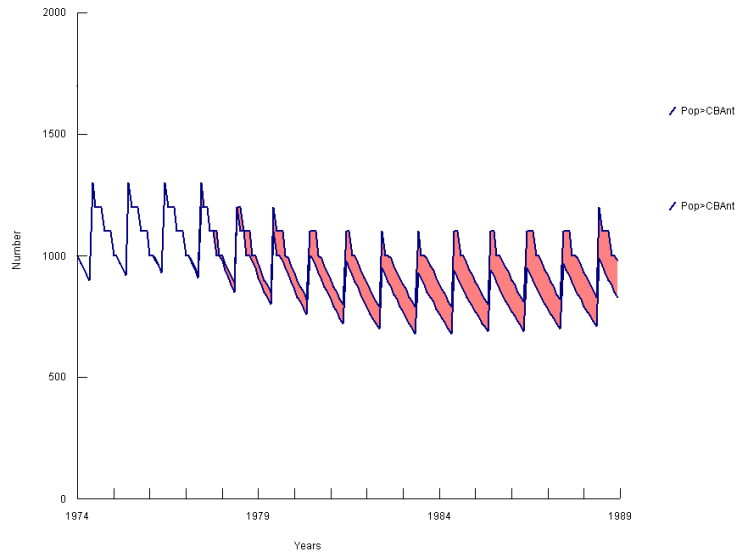




## Experiments - Dedicating Water to Lodges (continued)

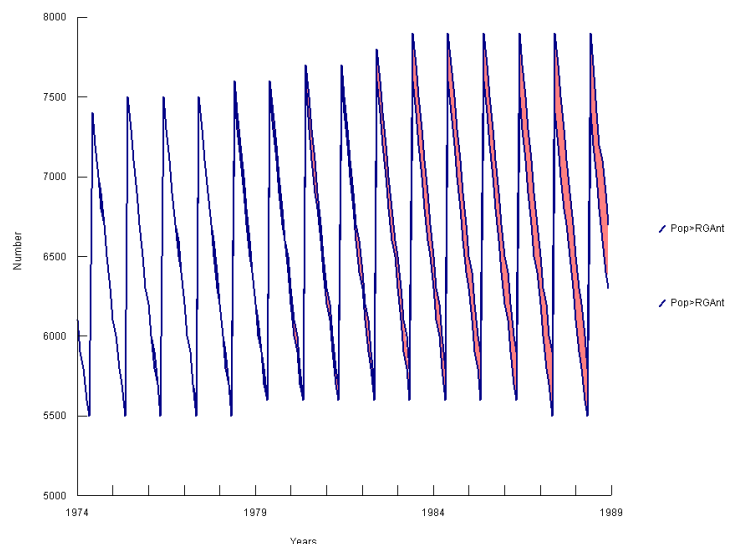
### *Crater browsing antelope population*

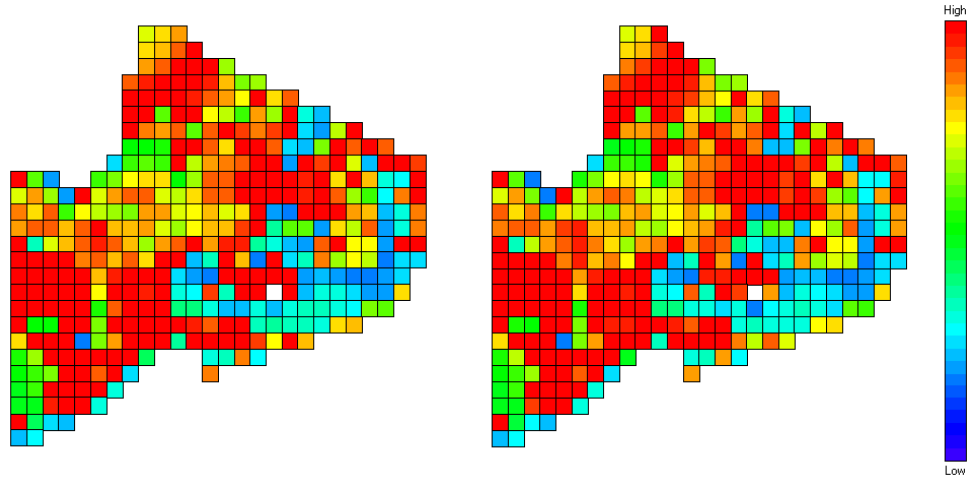
In general, changes in response to dedicating water sources within 1 km of lodges to those lodges had very small effects upon wildlife, livestock, or vegetation. This might be predicted from the small change in the distance to water, from 10.2 km to 10.5 km, when averaging across all the non-water cells.



Animals restricted to the crater did show decreases in their populations, as shown for crater browsing and resident grazing antelope.

### *Resident grazing antelope population*





*Accumulated offtake of vegetation from NCA for a typical year, with the Control model on the left, and with water dedicated to lodges on the right*

Small changes in the amount of herbivory in areas around the Ngorongoro Crater were demonstrated when water sources were removed, as shown above.

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