Experiments - Households and Agriculture

- Ngorongoro Conservation Area was created as a multi-use site, with management to balance the needs of humans and wildlife. The last estimate by the Ngorongoro Conservation Area Authority is that there are 51,621 residences of NCA, and that their population is growing at about 3% per year.
- In 1975 agriculture was outlawed in NCA, the was reinstated in 1992 on a temporary basis, and extended indefinitely in 1998. The effects of agriculture upon the Ngorongoro ecosystem is a contentious issue. Some consider cultivation within a conservation area inappropriate, whereas others cite the need to support the pastoralists encouraged to have a more sedentary life-style by policy changes.
- Savanna can be used to outline potential changes in the Ngorongoro ecosystem if agriculture is allowed to expand. Whether the predictions are precise or not, the model creates a common set of responses that people can frame discussions around.

Enabled household modeling



Enabled agricultural modeling



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The detailed household economic model has not been merged with Savanna, so a simple geometric model is in place temporarily. Households, by themselves, *do not affect* the system in any way. The agriculture associated with households is what causes changes in Savanna output. The amount of agriculture has been quantified in work associated with IMAS, and that value is in the default SavView file. Also in the default file is coded a 3% population growth rate.

Exercise: Using SavView, turn-on the household modeling, and turn-on agriculture. Leave the values at their defaults, since in the control model, no agriculture is the default. After the model completes, compare the control model to the changes in plants and animals with cropping and a 3% population growth rate in place.

Notes: This simulation may take as much as an hour to complete, depending upon the speed of the computer. A completed analysis is stored upon the accompanying CD disc.



The growth in households (left) and agriculture (right) when human population growth is at 3% annually.

Households at the beginning (left) and end (right) of the simulation.

Households and

agriculture are placed in the Savanna model based upon their

distribution in a 1991 aerial survey of households. In general, the midlands and highlands of Ngorongoro Conservation Area are occupied in the model. In the 15 years at 3% growth, agriculture goes from about 4,750 ha to 7,300 ha.

Agriculture at the beginning (left) and end (right) of the simulation. Note that the red, densest cells have 4 hectares in crops 200 in each square kilometer.

Numbers of warthogs

NCA and its 5 km buffer used in NCA-Savanna, cover about 10,000 km2, or 1,000,000 ha. Cropping in the 15 year model went from about 0.5 percent of the area to 0.75 percent. As might be expected, the

changes in livestock and wildlife populations is small in NCA-Savanna. The example shown, warthog populations, shows a decline in response to increased agriculture.

Experiments - Households and Agriculture (continued)

- We've seen that the changes in the Ngorongoro ecosystem when agriculture was put in place were relatively small. This might be predicted given that less than 1% of the site was being cultivated at the end of the 15 year simulation.
- As an experiment, we may ask what the response of animals might be to agriculture at various levels, such as from 0.5% up to 5%. We will set each household to have 5 ha of agriculture, which is above the average, but not by a great deal, and add households through a series of 10 simulations. The simulations will have human population growth rate set to zero (not changing) and, given that the NCA and its 5 km buffer are about 10,000 km², the number of households will be:

Households	Cropping (ha)	Agriculture (%)
1,000	5,000	0.5
2,000	10,000	1.0
3,000	15,000	1.5
4,000	20,000	2.0
5,000	25,000	2.5
6,000	30,000	3.0
7,000	35,000	3.5
8,000	40,000	4.0
9,000	45,000	4.5
10,000	50,000	5.0

Wildlife and livestock populations will start-out at the same level for each of these model runs, but will likely end the 15 year simulation at different levels. We need to select a point in time to compare the

various runs, so we will compare the populations at the end of the simulations. The changes in plants and animals, compared across the 10 simulations (plus the control model with zero agriculture), will suggest what the effects of up to 5% of NCA in agriculture would be.

Exercise: As a group, we will review the effects of putting up to 5% of Ngorongoro Conservation Area in cultivation. We will be comparing changes in livestock and wildlife numbers, and judging how the costs of having agriculture in place might weigh against its benefits to residents.

Notes: As we have seen, there are many ways to look at the output of Savanna, only some of which SavView allows. Here, we are combining the results of 11 simulations to create charts showing changes across a range of values. Often when summarizing Savanna results for presentation or study, we do file manipulation such as this.

Average populations of rare wildlife in the final year of simulation, for 0.5% to 5% agriculture

In general, the declines in livestock and wildlife in response to agriculture of 0.5% to 5% were

modest. Some groups declined significantly, however, such as elephants shown above. The declines would become more significant as agriculture increases, with populations reaching zero when the entire area is in crops, by definition.

Variations in the density of houses in the model will change the effects of agriculture on livestock and wildlife - there is not a single result from these analyses.

Presenting Savanna Results

We've seen that Mike Coughenour's Savanna produces an impressive array of output. In general, however, that output requires formatting and explanation to be useful in making policy decisions. When an individual or small group is using Savanna to address management question, the outputs from SMS and SavView are typically adequate to illustrate model responses. When presenting results to larger groups, further interpretation is often needed. Equally importantly, those using Savanna results in discussions should be aware of the nature of the model, at least in the generalist of ways.

Technical Matters

- There are several means to place Savanna output into a form appropriate for large audiences or reports:
- An easy way to modify SavView output is to make screen captures of the program, and change or combine output in what is called a Paint program. Using such a program, you may make whatever changes or additions to the output that you wish, including making a dark background for a slide, adding a large title, or explaining some portion of the image. The methods to do this are included in the exercise that follows.
- We regularly will import the tabular data from Savanna into spreadsheet programs, such as Microsoft Excel. The bulk of output from Savanna is in what is called 'comma delimited' ASCII format, meaning that the files are in a simple text format, with commas separating each of the columns of output. In general the format of the files is straightforward, although some do require

small changes to be read well by Excel. Once the files are in a spreadsheet program, professional quality graphing methods are available. The files can be sorted, graphed, or specific lines of output can be extracted, to be combined with output from other runs, for example.

Exercise: Display a map in SavView, any map or set of maps you would like. Then press <SHIFT><PRINT SCRN> at the same time. That places a copy of the entire computer display in a temporary storage space called the Windows Clipboard. Open the Windows program Paint under the Accessories menu entry, and under Edit, select Paste. You will see that a copy of the computer display, including the SavView maps, are now in an image in Paint. If we wished, that image could be cropped, colors changes, and text added, to make an informative and attractive slide or insert for a report.

Notes: The Windows Paint program is very simple but limited in what it can do. If you find the method helpful, there are more advanced paint programs available.

Presenting Savanna Results (continued)

Technical Matters (continued)

- The maps used in SavView to show inputs into Savanna are simple images, stored within the \SavView\Bitmaps directory. They may be used directly to make slides or for reports, if you wish.
- Sometimes we combine the results of several simulations. The example we have seen is running 10 simulations, with different levels of agriculture, but using only the ending population levels. In general, output from each analysis can be imported into a spreadsheet program, and the values of interest saved in another document.
- Savanna produces maps in its own, compact format. They cannot be used directly in geographic information systems (GISs). However, both SMS and SavView can export these maps into formats that can be used by IDRISI, ArcView, or ARC/INFO. To reach these utilities in SavView, go to "File" and select "Export results..." A window will appear with more information.
- Lastly, the printing tools in SavView are being developed, but the graphics SavView produces may be sufficient to illustrate your points.

Presenting Savanna Results

Many of those you show Savanna products to will be unfamiliar with ecosystem modeling, spanning from not understanding some particular trait of the model, to not understanding why a year's worth of ecosystem changes may be estimated in anything under a year. We must ensure that there is some minimal understanding of the results that we show. Using care when preparing and presenting materials can help avoid confusing those entirely unfamiliar with modeling.

Those misinterpreting Savanna or its results typically do so in predictable ways:

Some take the model output to represent what will truly happen, without questioning the results. Savanna is a useful tool for summarizing what may happen in response to a management decision. That said, the model remains an approximation of what may happen, not an "ecosystem in a box." Oddly, two opposing things contribute to why the model may not predict precisely what may happen in the ecosystem. First Savanna is extremely complex, including hundreds of variables and dozens of formulas, each with its own associated error. Balancing the model remains to be explored. Second, Savanna excludes portions of the ecosystem as a simplification. For example, in the NCA-Savanna model, all palatable species of grasses are collapsed into a single functional group, and predators, birds, and small mammals are excluded.

Presenting Savanna Results (continued)

• Some people have great knowledge about a particular aspect of the ecosystem, such as a small patch of land. If the model does not predict what might happen in that patch of land, they may discount the entire set of results. A common example is from vegetation mapping. If a particular grid cell in the Savanna map does not show what the person knows to be present at that cell, they may discount the map entirely, and perhaps even the potential uses of Savanna. Another example might be a small change in an animal population that is not shown in Savanna.

Encourage those using Savanna results to consider those results as a whole, over the entire Ngorongoro Conservation Area, as the model was parameterized. The question they should ask should not be "Do the results exactly match what I have seen at my favorite camp site?" but rather: "Do the general trends represented seem reasonable?"; "Are there unexpected results shown, but in hind-site are reasonable?"; and "Would these results form a starting point for discussions between stakeholders?"

- People viewing results should keep in mind that producing a valuable Savanna model for a site is an iterative process. As the model improves with each version, the predictions it makes provides a framework for evaluating the consequences of management decisions. As those decisions are adopted or abandoned, and the predictions of Savanna evaluated, the feedback may be used to improve the model.
- In general, however, the feedback regarding Savanna and its Ngorongoro application has been positive. Some of the most common comments received have been on ways to make the model more inclusive, and applicable to more problems.

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Exercise: As a group, we will discuss what management decisions might best be addressed using the Savanna Modeling System, and what management decisions would not be appropriate to address with Savanna.