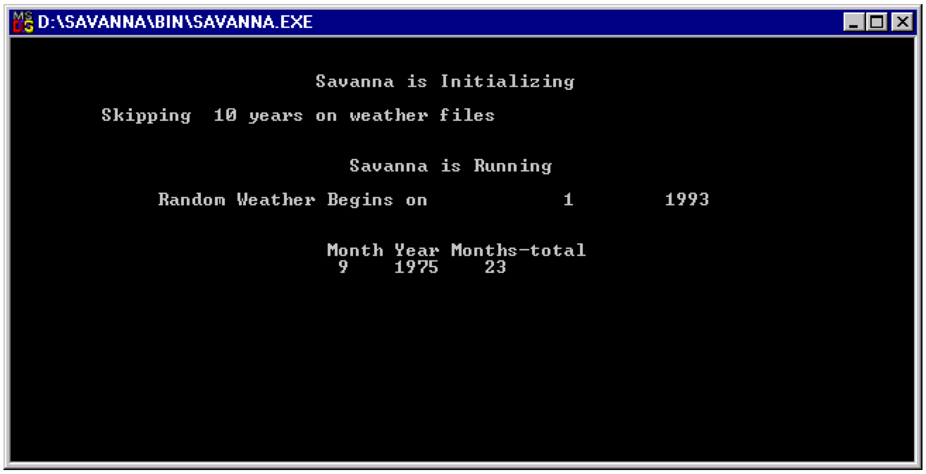
Ecosystem Modeling in IMAS

Savanna

Spatial Methods

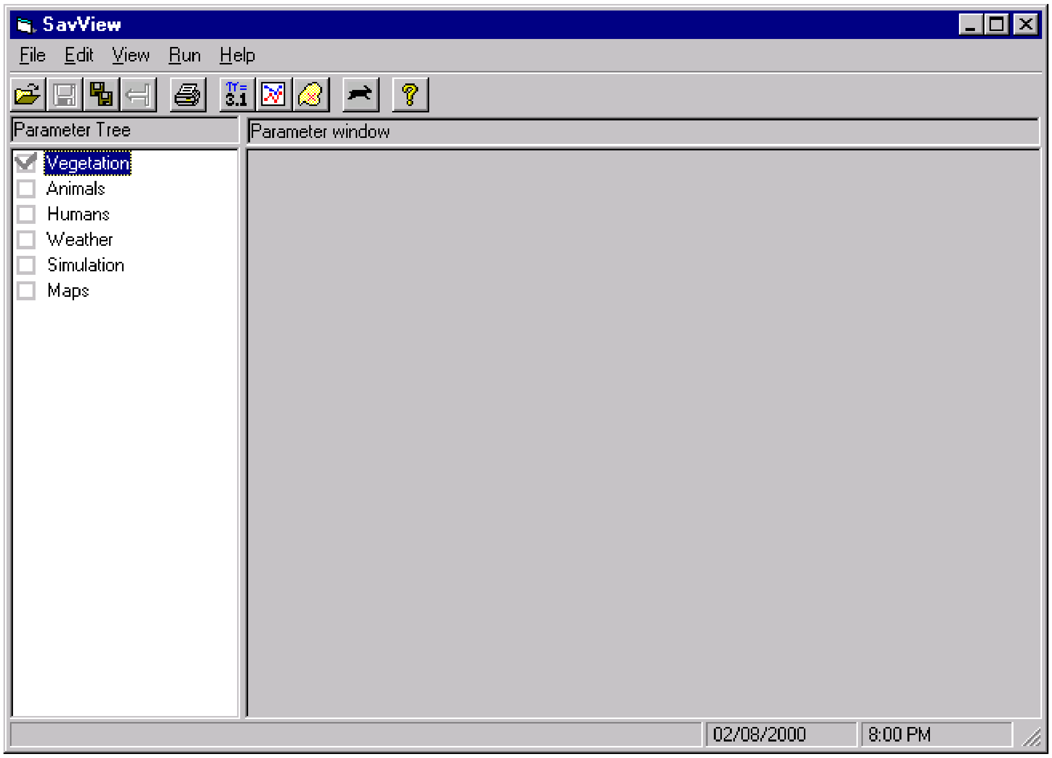
Three Primary Tools used in IMAS Ecosystem Modeling

Savanna: Thousands of lines of computer code implementing a suite of ecological relationships drawn from research and the literature.

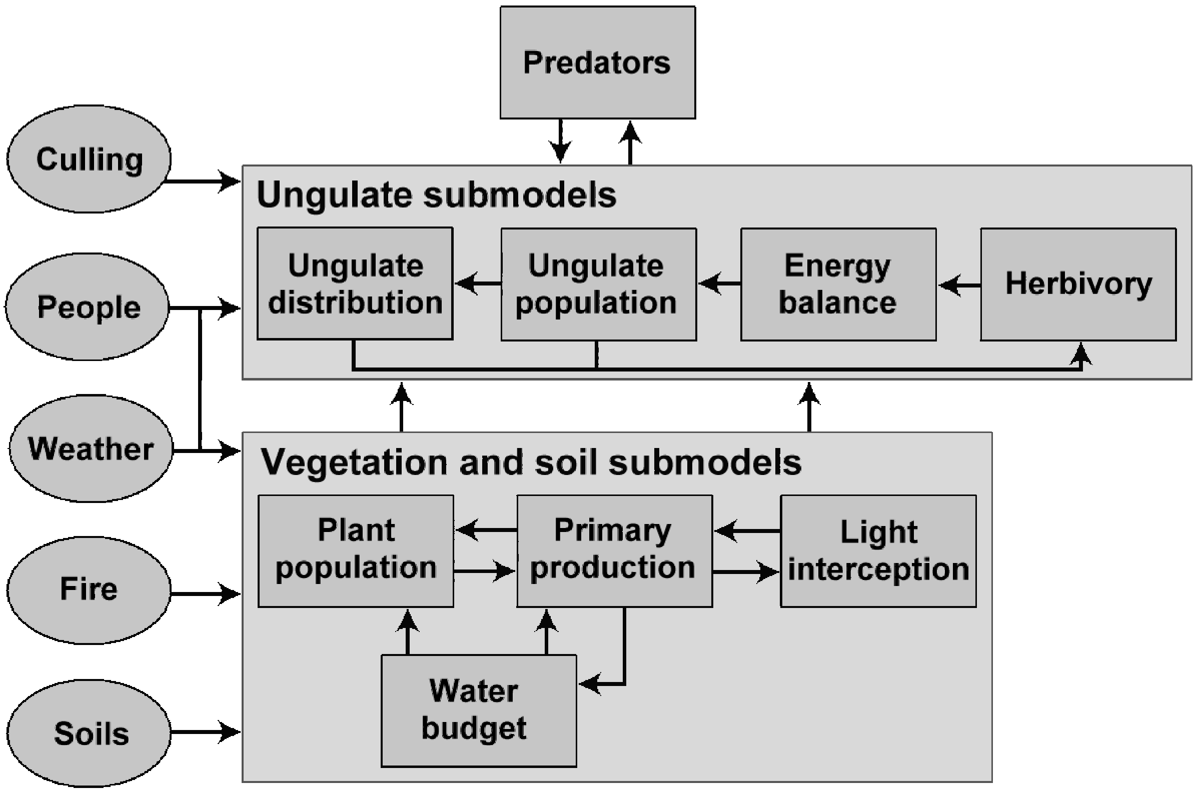


SMS: The Savanna Modeling System, an interface (menu-driven computer program) originally used to modify Savanna. Now SMS is used to look at detailed output from Savanna.

SavView: A graphical user interface used to make changes to selected parameters in Savanna, run simulations, and look at simplified output from Savanna.



The Savanna Modeling System



The Savanna Ecosystem Modeling System is a series of interconnected computer programs (in FORTRAN) that model, in a spatial way, grassland, savanna, and forested landscapes. Savanna models the ongoing *processes* of an ecosystem.

Some ecological models use long time steps (years) and model thousands of years of responses. In contrast, some use very short time steps (seconds) and model days. Savanna is in-between these extremes, using a *weekly time step*. This allows the system to model changes over perhaps 10 years to 100 years.

Exercise: List five of the primary or contentious management questions of importance on the land areas you manage or are familiar with.

Exercise: As a group we will review your list and that of your colleagues, and consider if Savanna may be of value in addressing those management questions.

The Savanna Modeling System Directory Structure

```
D:
└ savanna
   ├ bin
   ├ utils
   └ sites
      └ nca
         ├ backparm
         ├ gisout
         ├ graph
         ├ map1000
         ├ map5000
         ├ output
         └ parms
            ├ nostatev
            └ withstatev
```

D: The drive identifier, often C: or D:

savanna: Contains the entire Savanna Modeling System

bin: Programs, such as savanna.exe, sms.exe, and SVPATHS.DAT.

utils: Utilities used to parameterize Savanna.

sites: Contains parameters and output for study areas.

nca: Parameters and output for Ngorongoro Conservation Area.

backparm: Stores a backup copy of parameters.

gisout: Maps exported into GIS format are written here.

graph: Files used by SMS to format graphs.

map1000: Maps used as input to Savanna, at 1,000 m resolution.

map5000: Maps used as input to Savanna, at 5,000 m resolution.

output: Savanna output is written here, including tables and maps.

parms: The parameters used when savanna.exe is run.

nostatev: Parameters used to generate initial conditions.

withstatev: Parameters used after initial conditions are generated. That is, a backup copy of parameters normally used in simulations.

Exercise: Look at the file SVPATHS.DAT in the D:\savanna\bin directory. The SVPATHS.DAT file tells Savanna the location of the directories to which it needs access.

Method: Use Windows Explorer to move to the D:\savanna\bin (or C:\savanna\bin) directory, double-click upon SVPATHS.DAT, and select the Notepad to view the file, if not already shown.

Notes: Incorrect paths in SVPATHS.DAT are often the reason new installations of Savanna do not work. When installing Savanna, ensure that the drive shown in SVPATHS.DAT matches the drive the software was installed on. For best results, install the software at the root of the drive rather than in a subdirectory, because overly-long pathways can cause Savanna to fail.

Savanna's Representation of Spatial Information

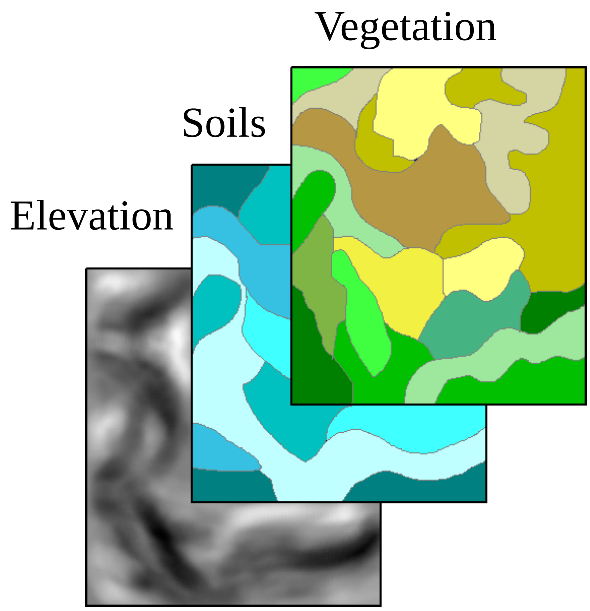
Geographic information system (GIS) maps cannot usually be used in Savanna as-is. The landscape must be divided into uniform patches of land, so that the model can be run for each patch.

Layers made of lines (vector) are converted to a grid-based system (raster), then converted to a common resolution, such as cells 1,000 m across or 5,000 m across. The maps used in Savanna must overlay each other, that is overlap, with the same number of rows and columns.

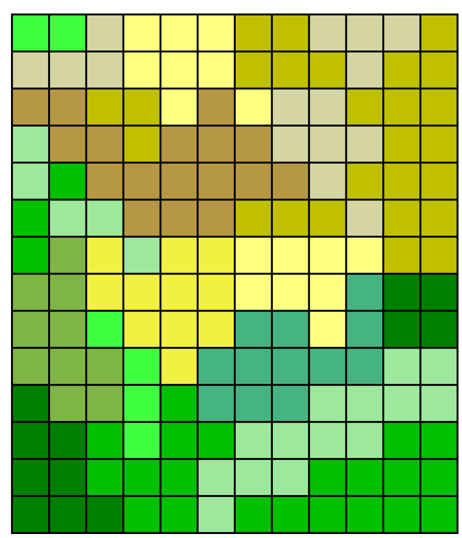
Maps used:

- Elevation
- Slope
- Aspect
- Soils
- Vegetation
- Distance to water
- Animal "force" maps
- Distributions of households
- \+ Weather station locations

GIS maps cannot be used directly



In Savanna, vegetation is represented as ...



Exercise: Look at the maps used as input into the default model for Ngorongoro Conservation Area.

Method: Start SavView, and under “File”, select “Open”. Select the file called “NCA Defaults.sva”. The ‘Parameter’ section of the program should be showing (if not, select “View” and “Parameters”). Then double-click the “Maps” entry in the tree on the left, and explore the “Geology” maps by clicking on that entry. In the window shown, the elevation, slope, aspect and soils maps can be viewed by clicking on the button of interest.

Notes: Savanna can use maps in IDRISI format, or in ARC/INFO GRIDASCII format. The maps in the Ngorongoro model are IDRISI format, and are stored in \savanna\sites\nca\map5000 or map1000. At 5 km resolution, maps for NCA, and a broad border, are 35 columns and 35 rows. At 1 km resolution, there are 177 columns, and 175 rows.

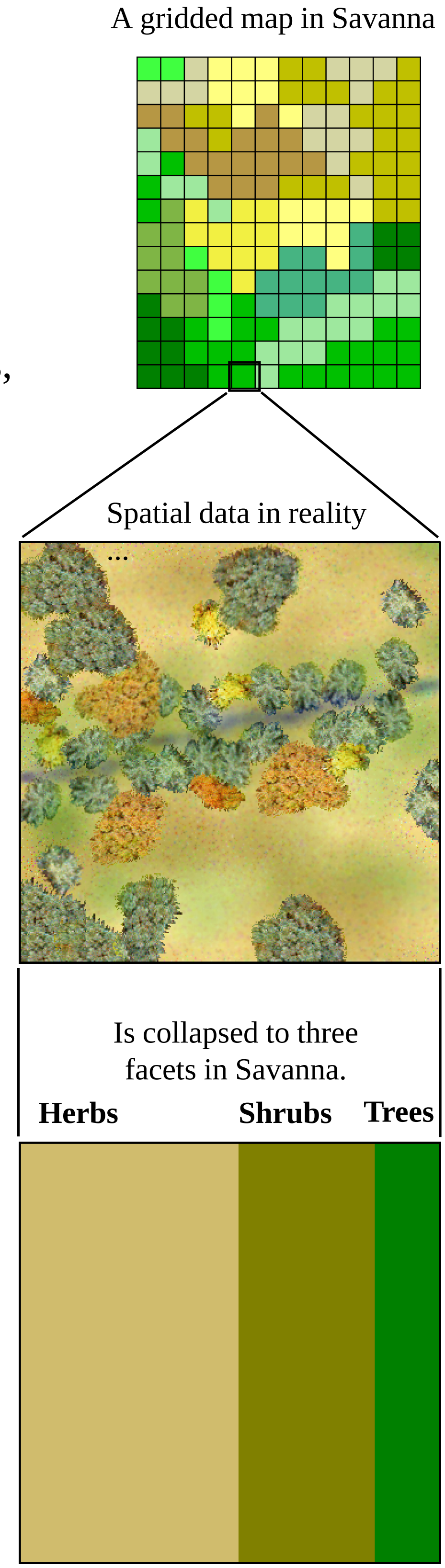
Savanna's Representation of Vegetation within a Cell

Savanna represents spatial data as a grid of blocks. Within each block, vegetation information must be represented with sufficient detail to model landscapes realistically, but not so detailed as to be too slow when modeled.

Some models represent individual plants, but that would be very slow when modeling hundreds of square kilometers.

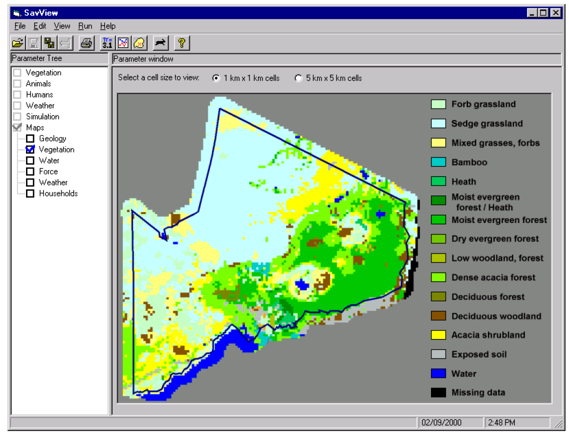
Instead, Savanna represents vegetation within each grid cell as proportions of subareas, and within each subarea are three *facets*.

The three facets (herbs, shrubs, and trees), are assigned initial proportions, but the proportions may change over a model run, as one facet shrinks and another expands, due to plant competition.



Notes: Savanna supports using more than one subarea. For example, a given habitat type may behave differently if it is in a run-off area than an upland. Each cell in the model would then have a run-off subarea and an upland subarea, with the proportion of each specified, and each subarea would have three facets. However, in recent applications of Savanna, including that for Ngorongoro Conservation Area, only one subarea is used. In essence, then, each grid cell simply contains three facets: herbs, shrubs, and trees.

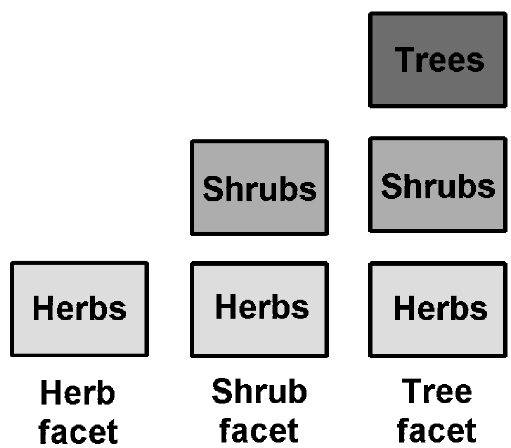
Initializing Facets within Savanna



To initialize vegetation modeling requires a vegetation map. The map is generally created using satellite images and whatever training information is available. Training information is accurate vegetation data for known locations on the ground.

Satellite images are classified by using the training to essentially teach computers what different colors in the satellite images correspond to which vegetation types. The computer can then classify the other portions of the image of the same color as the same vegetation. Each cell is one vegetation type, and contains three facets.

Facets are named "Herbs", "Shrubs", and "Trees", but each layer builds upon the previous layer. In other words, the herb facet contains only herbaceous vegetation. The shrub facet contains both a shrub layer and a herbaceous layer. The tree facet contains trees, shrubs, and herbs.



Initial conditions are set for each facet using FAC.DAT files. Each FAC.DAT file contains a list of the vegetation types on the site. For herbs, HERBFAC.DAT lists g / m^2 for herbaceous types. SHRUBFAC.DAT lists herbs, in the understory of the shrubs, as well as percent cover of shrub types. TREEFAC.DAT lists values for understory shrubs, herbs, and trees.

Exercise: Look at the vegetation maps used as input into the model for Ngorongoro Conservation Area.

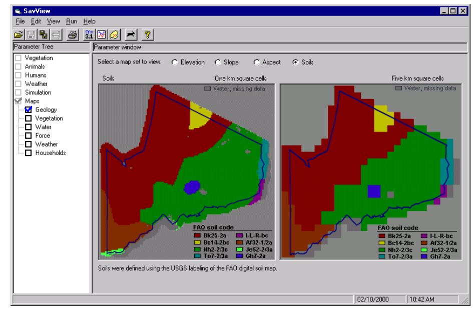
Method: Use the method described on page 17, clicking upon “Vegetation”. Dr. Mohammed Kalkhan of NREL, CSU, classified the image to 27 vegetation types, which were reduced to 15 types.

Exercise: Look at the files HERBFAC.DAT, SHRUBFAC.DAT, and TREEFAC.DAT in the “parms” directory.

Method: Use Windows Explorer to move to the \savanna\sites\nca\parms directory, double-click upon the files, and select the Notepad to view the file, if not already shown. These FAC files initialize the cover in each facet, in each cell. Savanna ignores anything on a line that is to the right of “//”, and the comments at the bottoms of files. These comments help to clarify the meaning of values in parameter files.

Main Files controlling Spatial Modeling in Savanna

The soil map used in Savanna does two important things. It describes soils to Savanna, as you would guess, but it also defines the study area boundary. Cells in the soil map that have a value of zero are not considered part of the study area.



Spacedat.prm sample

The parameter file SPACEDAT.PRM tells Savanna the dimensions of the study area and names the facets. The file also tells Savanna for which cells the analyst wants diagnostic information. Diagnostic output is more detailed than the summaries Savanna normally produces.

```
&spacedat
irowcol=1                   !/ 1-use Idri
nfrow=0       ! 0           !/ First row
nlrow=34      ! 174         !/ Last row i
nfcol=0       ! 0           !/ First colu
nlcol=34      ! 176         !/ Last colum
nsubar=1                    !/ Number of
nfacet=3                    !/ Number of
irunof=0                    !/ Flags desi
sbname(1)='Upland'          !/ Name of su
fcname(1)='Open'            !/ Name of fa
fcname(2)='Trees'           !/ Name of fa
fcname(3)='Shrub'           !/ Name of fa
ndiagt=1                    !/ Number of
nrdiag=12                   !/ Row of dia
ncdiag=12                   !/ Col of dia
nfdiag=1                    !/ Facet of d
nsdiag=1                    !/ Subarea of
nspdiag=1                   !/ Plant spp
ilocsfl=1                   !/ Ilocsfl -
nrpop=-1                    !/ Save anima
ncpop=-1                    !/ Save anima
&
```

Mapprm.prm sample

The parameter file MAPPRM.PRM tells Savanna which maps to use for the GIS layers, and which seasons to use them.

```
&mapprm
...
outmask='                           '
elevmap='elev5000.img               '
slopemap='slop5000.img             '
aspectmap='aspt5000.img          '
pptmap='None                     '
vegmap='veg5000.img              '
herbmap='                          '
soilmap(1)='soil5000.img             '
subarmap(1)='sub5000.img                '
...
&
```

Exercise: Look at the soils maps used as input into the default model for Ngorongoro Conservation Area.

Method: Use the method described on page 17, clicking upon "Geology", then in the large window to the right, select the button that displays the soils. Beyond informing Savanna about soils, the soil map also defines the limits of the study site. Any cell in the map with a value of zero is considered outside the study area.

Exercise: Look at the MAPPRM.PRM file in the "parms" directory.

Exercise: Look at the SPACEDAT.PRM file in the "parms" directory.

Method: Use Windows Explorer to move to the \savanna\sites\nca\parms directory, double-click upon the files, and select the Notepad to view the file, if not already shown. Just as everything to the right of "//" on a line is ignored by Savanna, so is everything to the right of "!/".

Simulation Control in Savanna

Simcon.prm

Of course, each of the files in Savanna's parameters directory controls the simulation. However, one file, SIMCON.PRM, controls the basic nature of the simulation and how much data is output.

SIMCON.PRM includes many things, such as switches to turn on and off population modeling, the dates to be modeled, whether given files should be output, and whether or not households and agriculture should be included.

```
&simcon
nspcon=   17            !/ # herbivore species
ipopfix=  0,1,0,1,0,0,0,1,0,0,0,0,0,0,0,0,0 !/
hpopfile= 'dens.dat  '  !/     Name of herbivore
hpopkm2= 10175.         !/     Area (km2) in whi
nscdia=   1             !/     Index of animal s
ipopout=  1             !/     Consumer pop. out
ihdenimg= 1             !/     Units of herbiv.
iwmodl=   0             !/     Flag 1 if a wolf
ipmodl=   0             !/     Flag 1 if a pasto
isens=    0             !/     Flag set to 1 if
ifiref=   0             !/     Flag, 1 if fires,
iwthr=    2             !/     1-use ppt on the
wthfile=  'sr356392.wth'!/     Name of the ascii
mwthfile= 'weather.prm' !/     Name of main base
bpptfile= 'ppt6392.mrg' !/     Name of multi-sit
bdatfile= 'basestn.dat' !/     Name of file with
iranw = 1               !/     Flag to use rando
nmranwth= 1             !/     Month to begin us
nyranwth= 1993          !/     Year to begin usi
ndtmn=  4               !/     # time steps/mont
mstrt=    11            !/**** Start month
nmnths=  180            !/     Months to run  (4
nystrt= 1973            !/     Start year
mstrtp=   0             !/     First month to st
dtpmon=   1             !/     Month interval to
dtprn=    1             !/     Year interval to
maccum=   0,0,0,0,0,0,0,0,0,0,0,1 !/ Flag the mo
imgsav=   1             !/     Flag 1 to save im
nfout=    0             !/     Facet to save on
nsout=    0             !/     Subarea to save o
nfgimg=   1             !/     Flag 1 to save im
imgcon=   1             !/     Flag 1 for image3
idistrd=  0             !/     Flag 1 for distri
ncout=    0             !/     Consumer spp. for
imgmon=   1,1,1,1,1,1,1,1,1,1,1,1 !/ imgmon - mo
iswin=    3             !/     Flag 1-initialize
ifcout=   0             !/     Facet for output
isbout=   0             !/     Subarea for outpu
iseed=    0             !/     Random number see
ivegacc=  1             !/     Accumulate by Veg
initree=  1             !/     1-init trees from
imgtree=  0             !/     To produce output
myrsp=    ','           !/     Separator between
numrunt = 0             !/     Number of runs (>
istatesv=2              !/     1-dump state vars
ispatial= 1             !/     1-spatial run, re
iagric= 0               !/     1-Model agricultu
idisease= 0             !/     Flag to store wee
&
```

Exercise: Look at the SIMCON.PRM parameter file in the “parms” directory.

Method: Use Windows Explorer to move to the \savanna\sites\nca\parms directory, double-click upon the files, and select the Notepad to view the file, if not already shown.

Notes: Several of the entries in SIMCON.PRM are switches. If a value of 0 is set, a portion of Savanna is not used. If a value of 1 is set, the portion of Savanna is used. This is an example of *modularity* in Savanna. One way to adapt Savanna to many different sites is to allow parts of the model to be used or not.