Savanna Landscape Engineering:

What forms are possible or desirable in an uncertain future?

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Savanna Science Network Meeting
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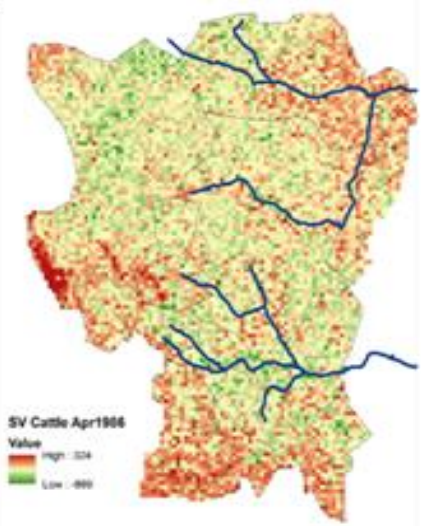
- Savanna agro/ecosystems can persist or change under human and climatic influences
- Management & policy covers many spatial and temporal scales
- How much pressure/change can these ecosystems withstand?
- Ecological Engineering Questions
  - What future states are acceptable/desirable?
  - What level of control do we (as humans) have on these ecosystems?

Overview

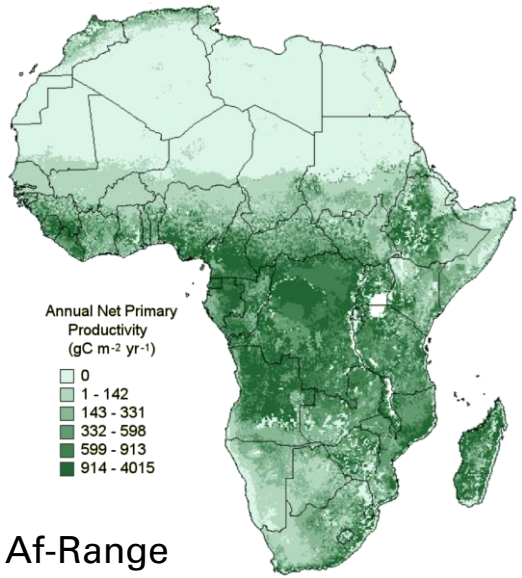
- Randy Boone (@CSU) has already introduced Af-Range/L-Range and its use across Africa (L-Range.com)
- Development of a more “local” version (Af-Range-KNP) to represent KNP-level management options
- Preliminary simulations using GCM-derived climate (“Historic”, R4.5 and R8.5) w/different elephant management
  - How does the vegetation (grass, shrubs and trees) respond?
  - How do the large herbivores respond?

Many open-source tools are available for exploring savanna dynamics

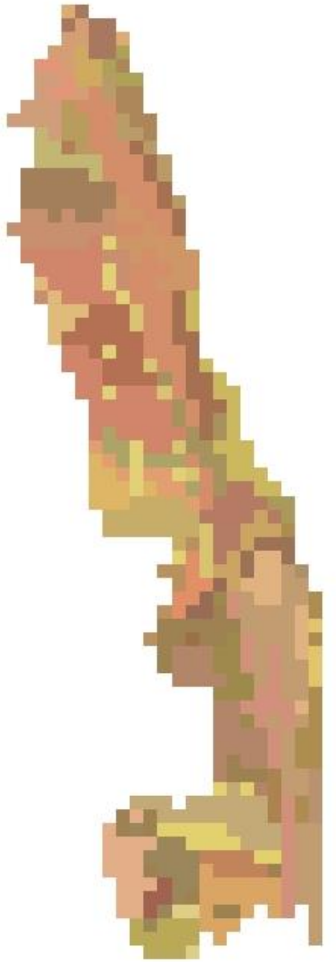
- Grid-based, deterministic models allow *comparisons ranging from point to park to regional to global scales*
- Grass, shrubs, trees, herbivores, fire *and humans* with spatial combinations (livestock- and conservation-based ecosystems)
- Open-Source models on local laptops with readily available spatial inputs
- Local partners/graduate projects



SAVANNA/DECUMA
Borena Ethiopia@ 1 km²



Af-Range
Africa@ 10 km²



SAVANNA
KNP@ 5 km²

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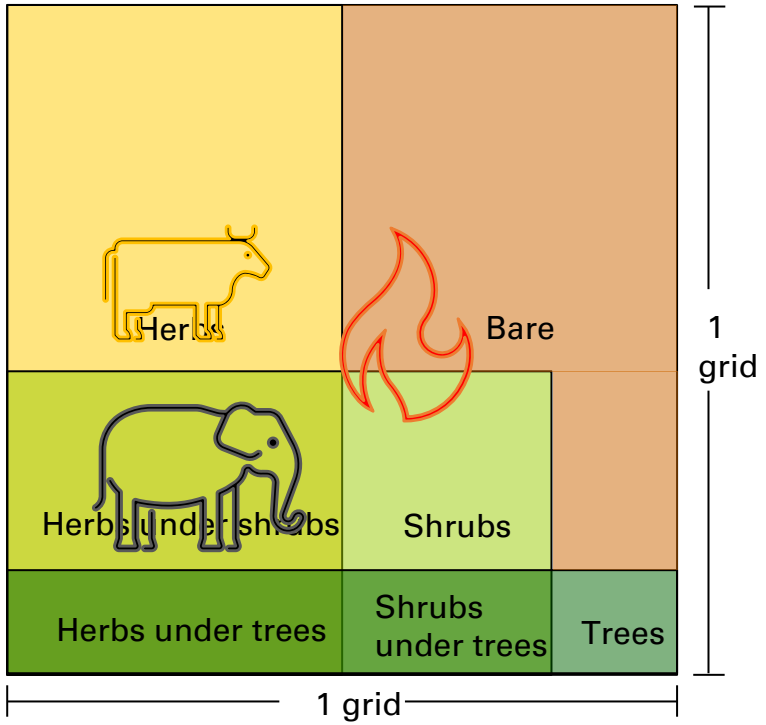
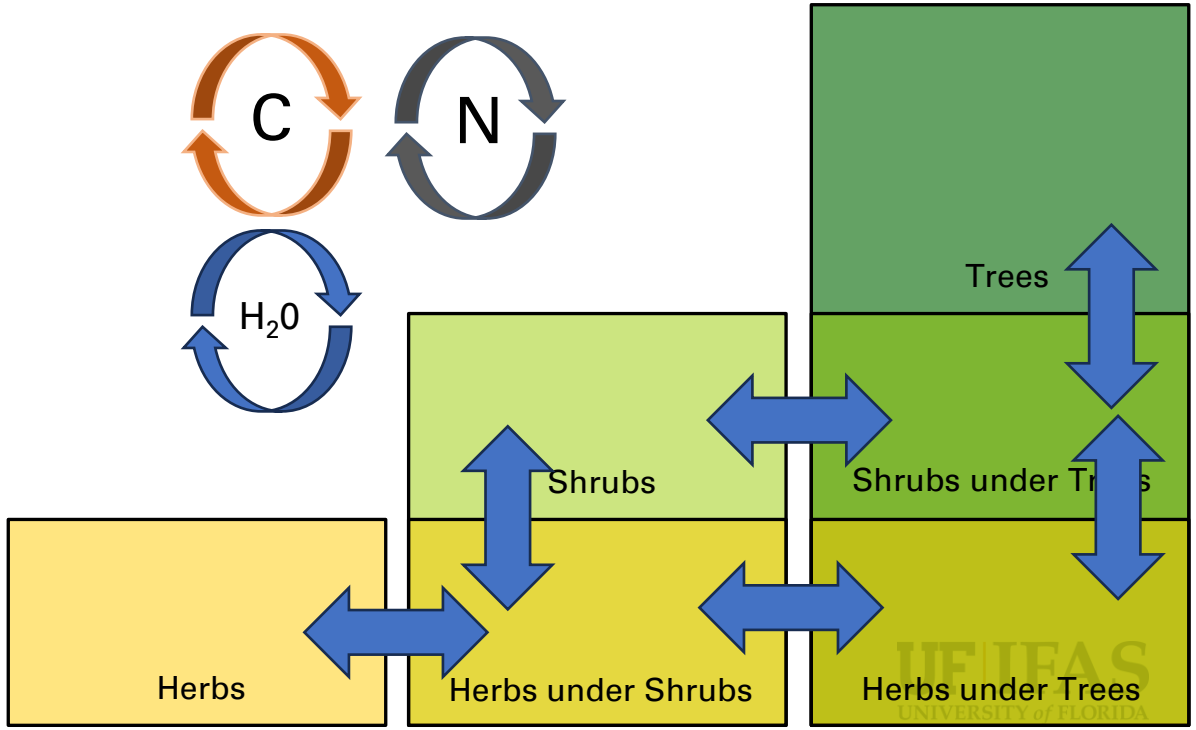
The G-Range, L-Range Family of Models

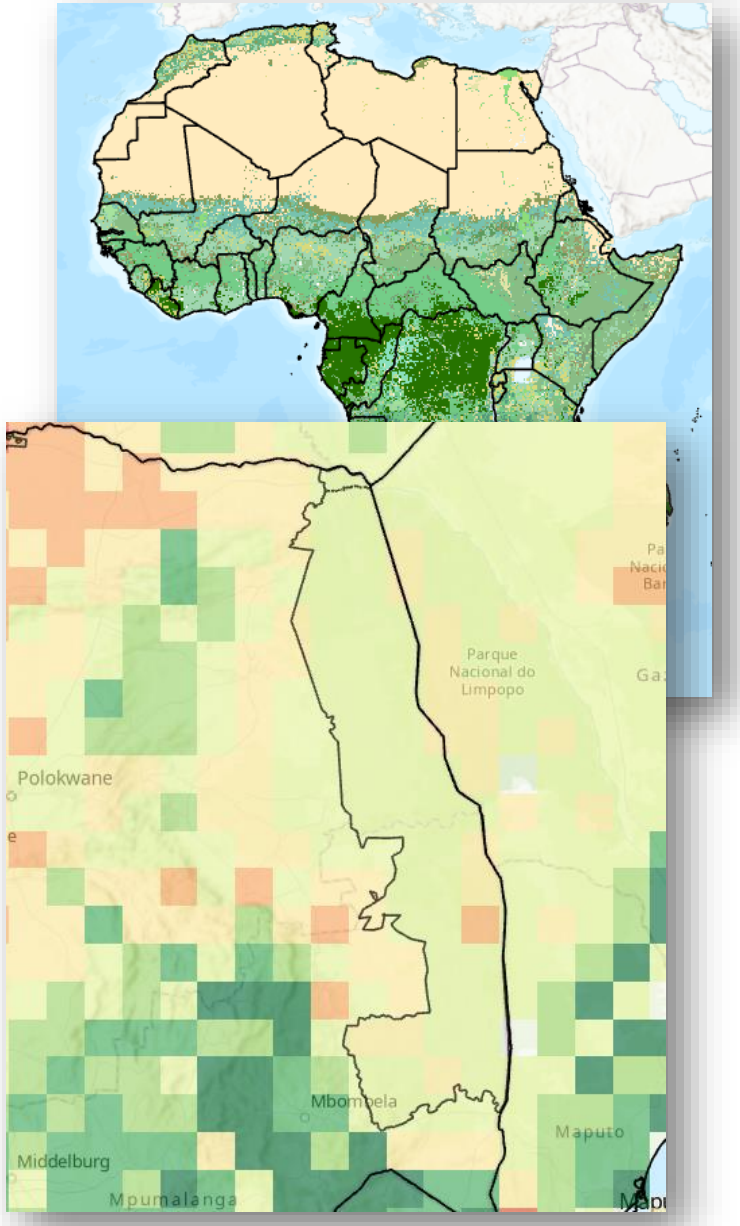
- Developed by Randy Boone (Colorado State Univ/Natural Resource Ecology Lab)
- Simplified from SAVANNA and CENTURY models
- Open-Source (github), Laptop Based (*l-range.com*)
- G-Range (Global Model), L-Range ("Local" Versions), Af-Range (@10-20km)
- Can be linked with Agent Based Models of humans
- Vegetation (3 groups, 6 layers, defined combos)
- Multiple herbivores, fire, C/N dynamics, etc…





Africa @ 20 km resolution

- **7 Primary Vegetation groups** (with 48 local variations): (1) Tree Cover, Broadleaf, Deciduous, Closed; (2) Tree Cover, Broadleaved, Evergreen, Closed To Open; (3) Shrubland; (4) Grassland; (5) Mosaic Herbaceous Cover; (6) Cropland, Rainfed; (7) Bare ground; (8) Water
- **5 Livestock groups** (Cattle, Goats, Sheep, Camels, Donkeys)
- **2 Wildlife** (Grazers and Mixed Feeders)
- **Fire frequencies and intensities** dependent on Vegetation Types
- **Outputs** over 300 maps created for each month
- There is also an Af-Range version @ 10km resolution



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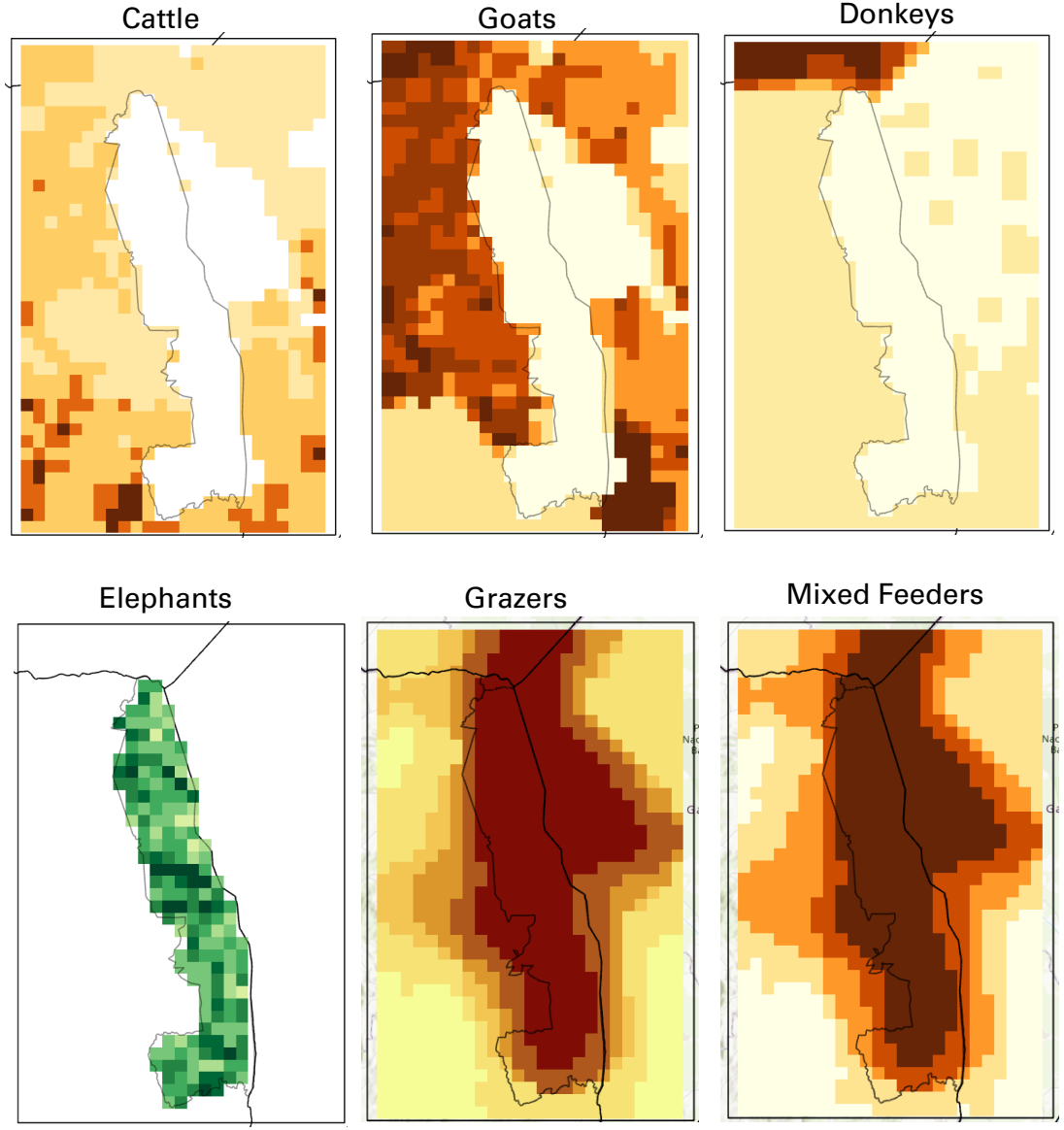
Af-Range KNP @10km

- **Same Primary Vegetation groups**
- **Fire Freq/Int**-same as Afr@10km
- **4 Livestock groups** (Cattle, Goats, Sheep, Donkeys)
- **3 Wildlife** (**Elephants**, Grazers and Mixed Feeders)
- Constant Herbivore Populations, ***but varying condition***
- Smaller resolutions are possible but require more detailed attention
- Modeling Experiments
  - 25k Elephants vs 50k elephants (based on Izak Smit's population density maps)
  - "Historical" Climate (100 years) **vs** 4.5 **vs** 8.5 Scenarios using the ACCESS model (with CO_2 effects) (1970-2070)
  - Fire uses a vegetation-based burn frequency & cover



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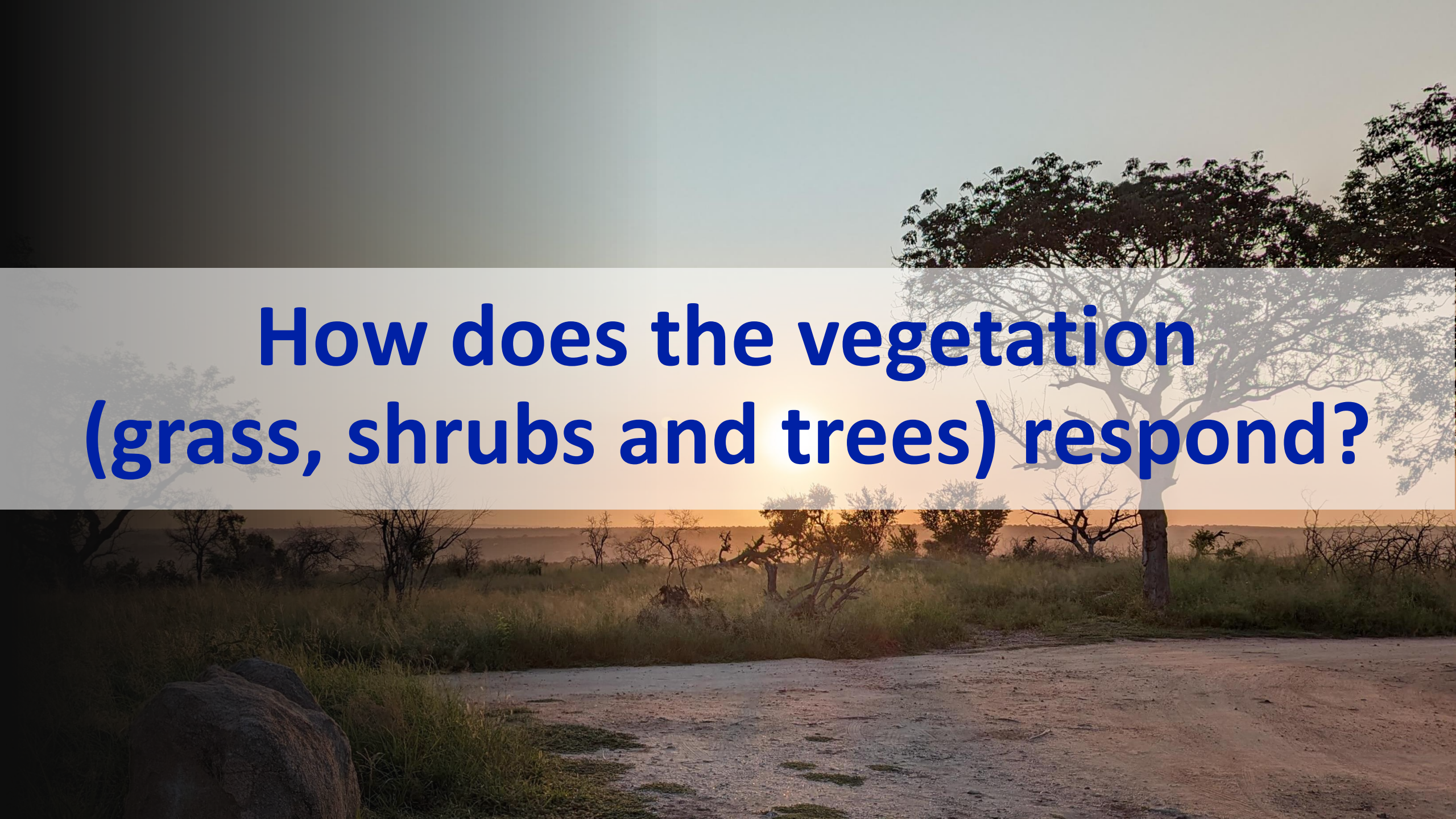
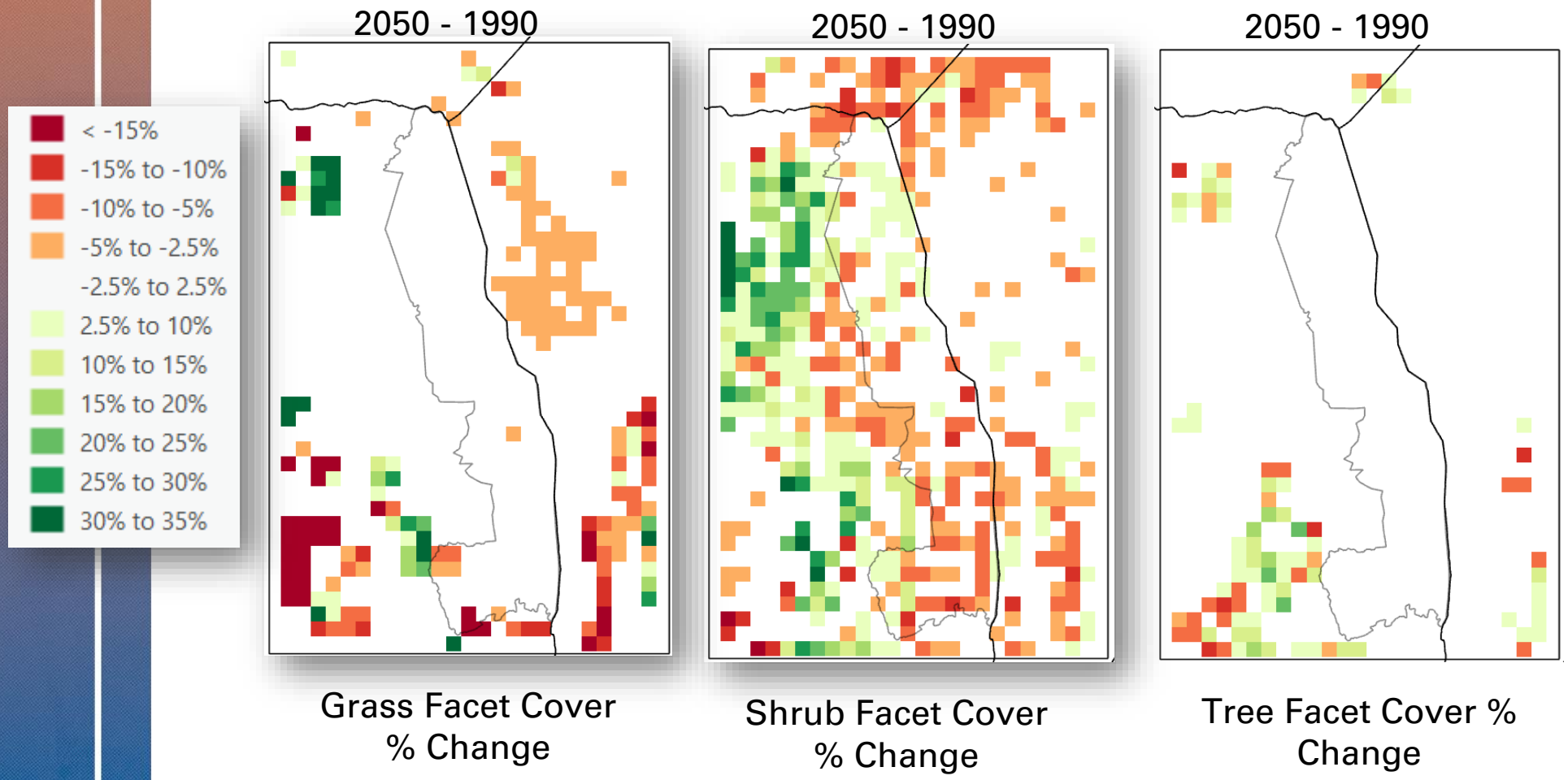


How does the vegetation (grass, shrubs and trees) respond?

Low Veld @ 10 km resolution

Climate Scenario: ACCESS 4.5/CO_2 – 25k Elephants

Future (2050) minus Past (1990)



Grass Facet Cover % Change

Shrub Facet Cover % Change

Tree Facet Cover % Change

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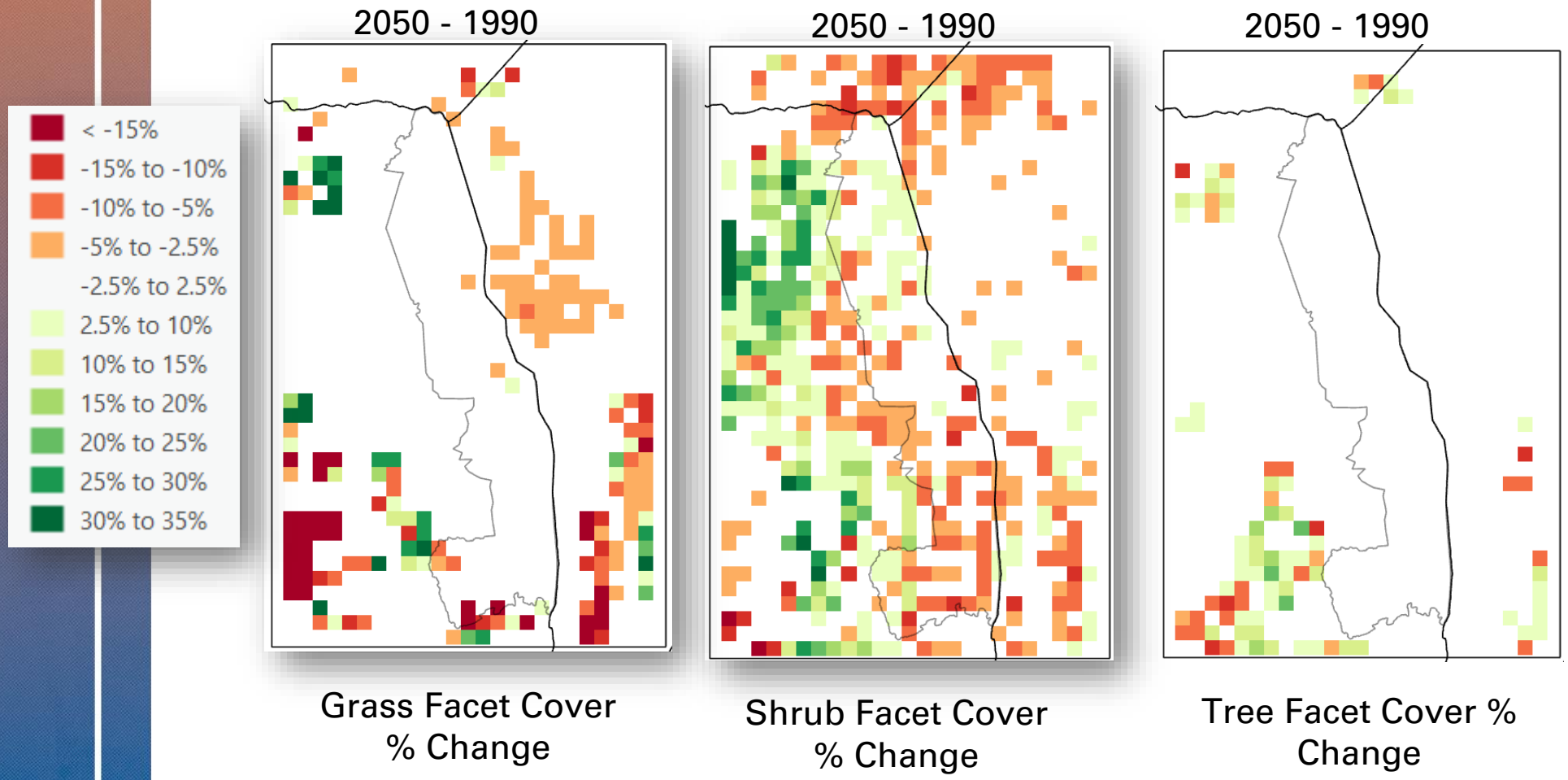
Low Veld @ 10 km resolution

Climate Scenario: ACCESS 8.5/CO_2 – 25k Elephants

Future (2050) minus Past (1990)



Grass Facet Cover % Change

Shrub Facet Cover % Change

Tree Facet Cover % Change

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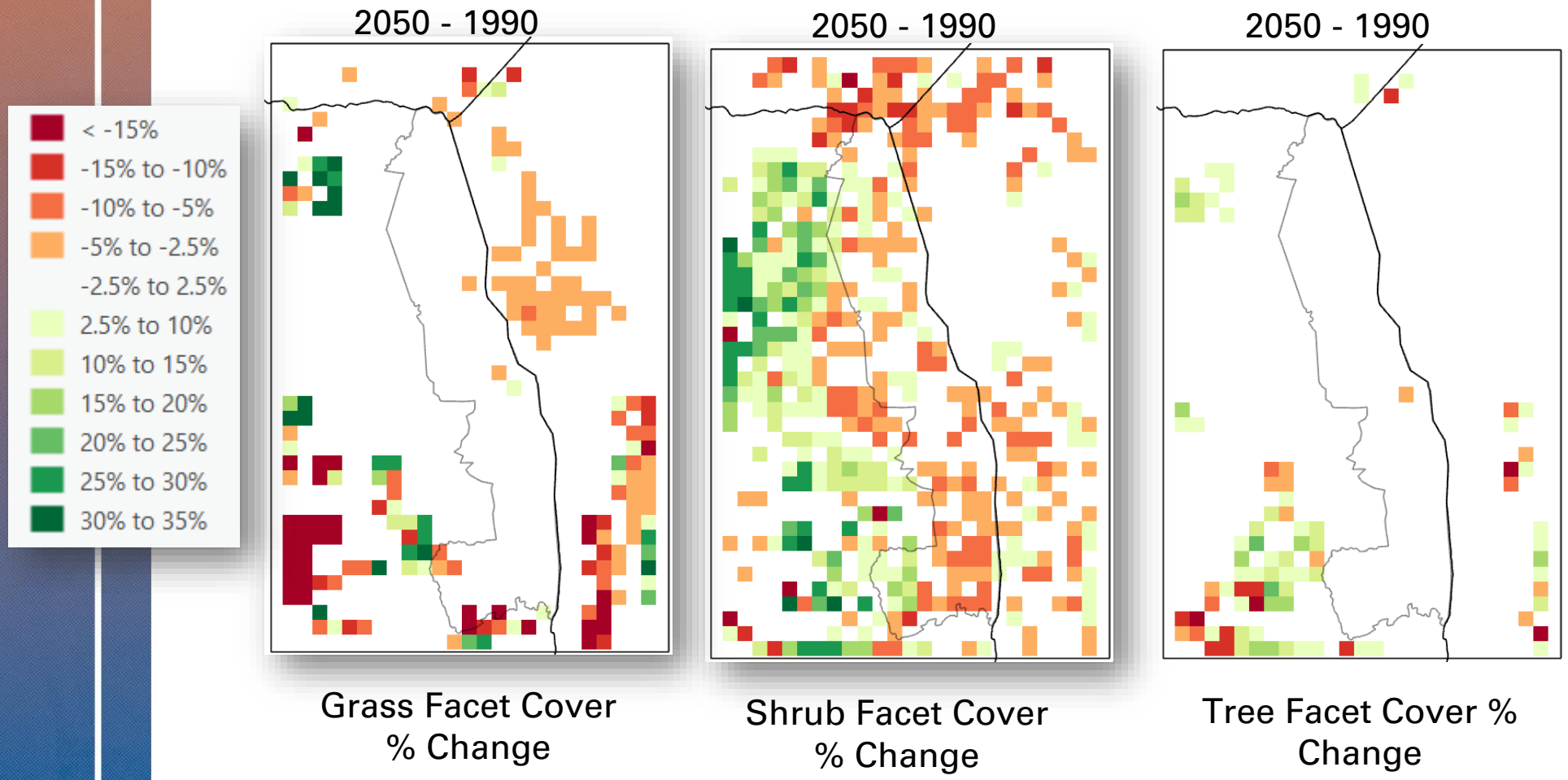
Low Veld @ 10 km resolution

Climate Scenario: ACCESS 4.5/CO_2 – 50k Elephants



Grass Facet Cover % Change

Shrub Facet Cover % Change

Tree Facet Cover % Change

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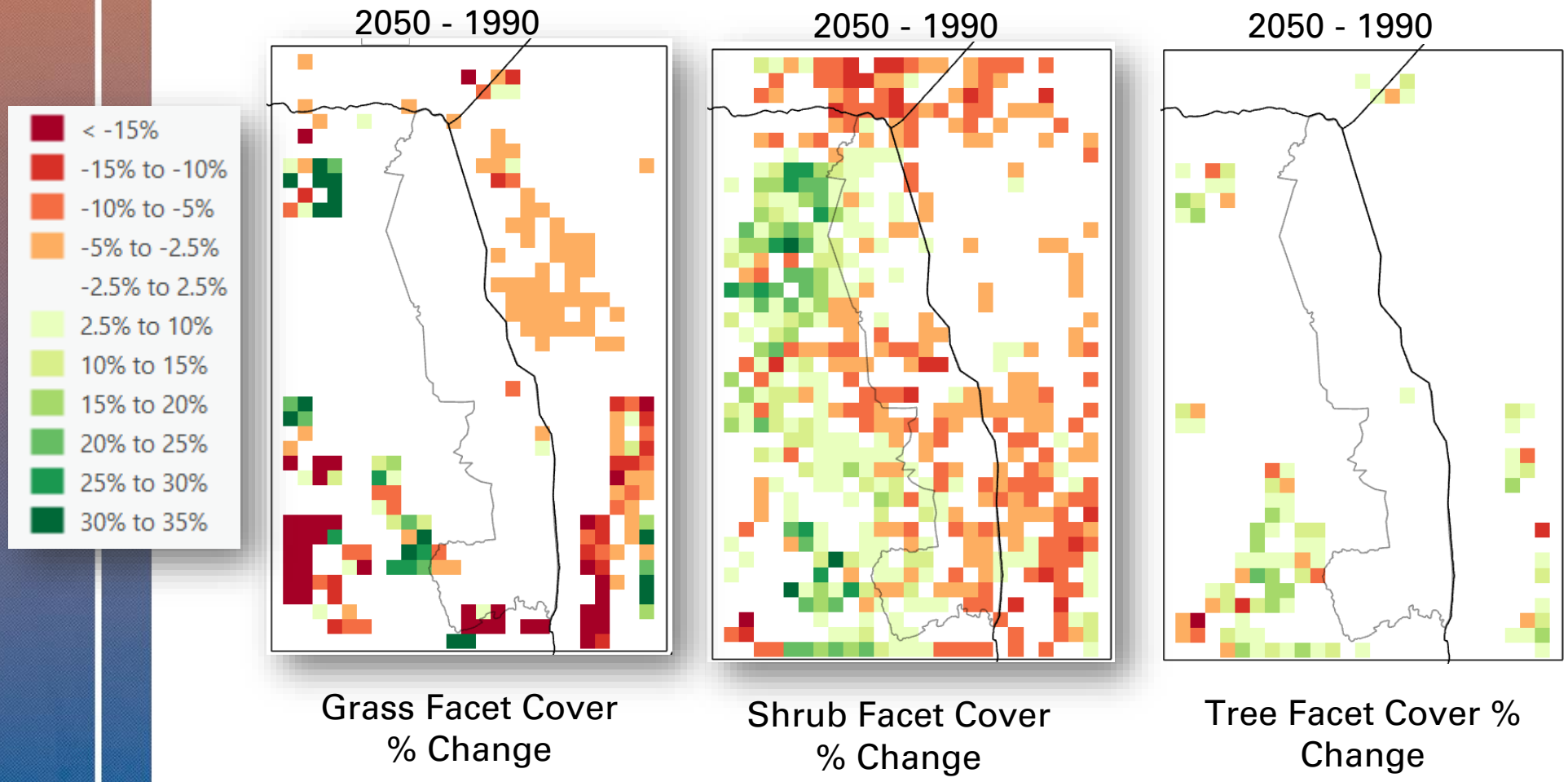
Low Veld @ 10 km resolution

Climate Scenario: ACCESS 8.5/CO_2 – 50k Elephants



Grass Facet Cover % Change

Shrub Facet Cover % Change

Tree Facet Cover % Change

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How do the large herbivores respond?

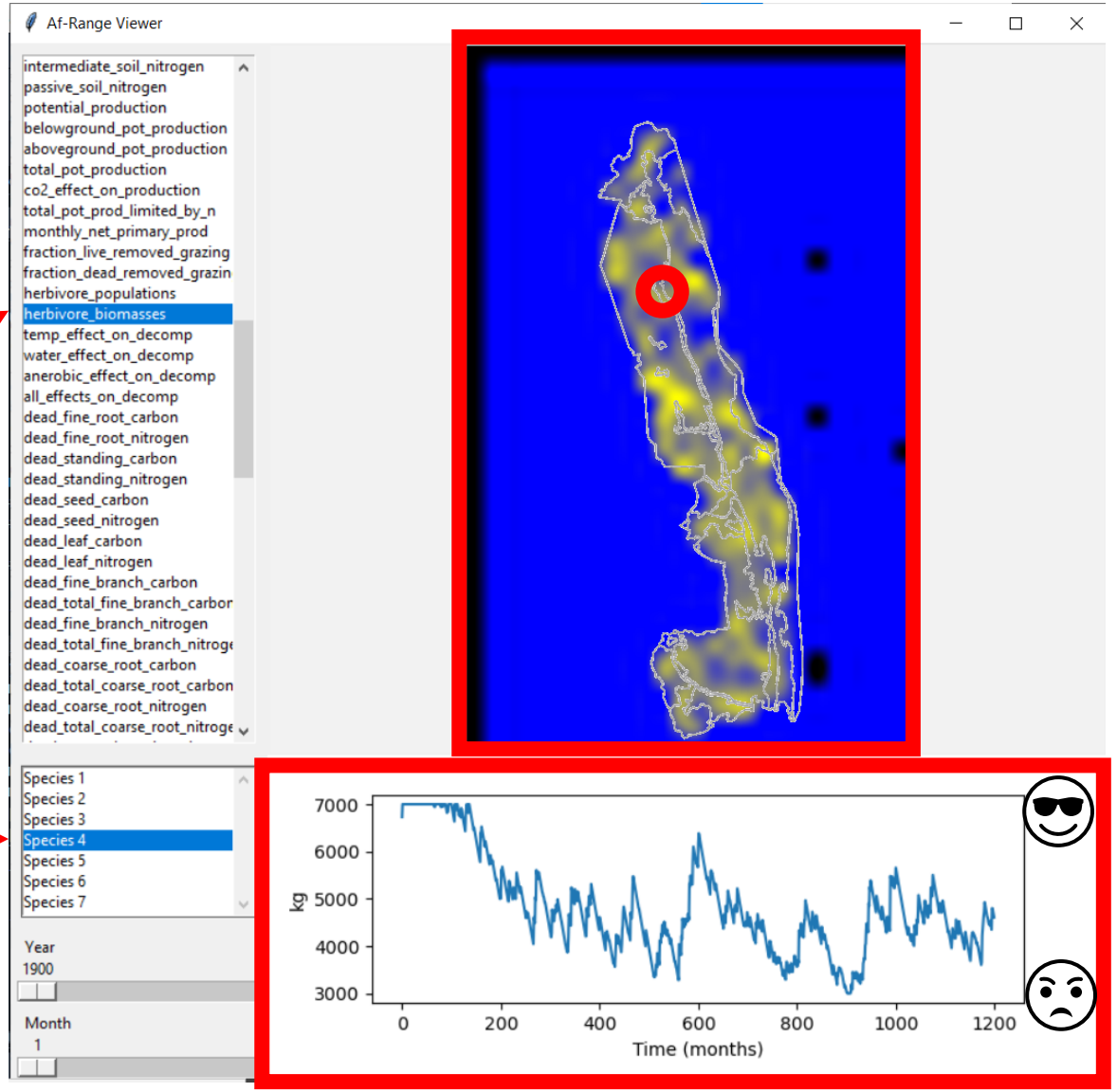
So how do herbivores respond to change?

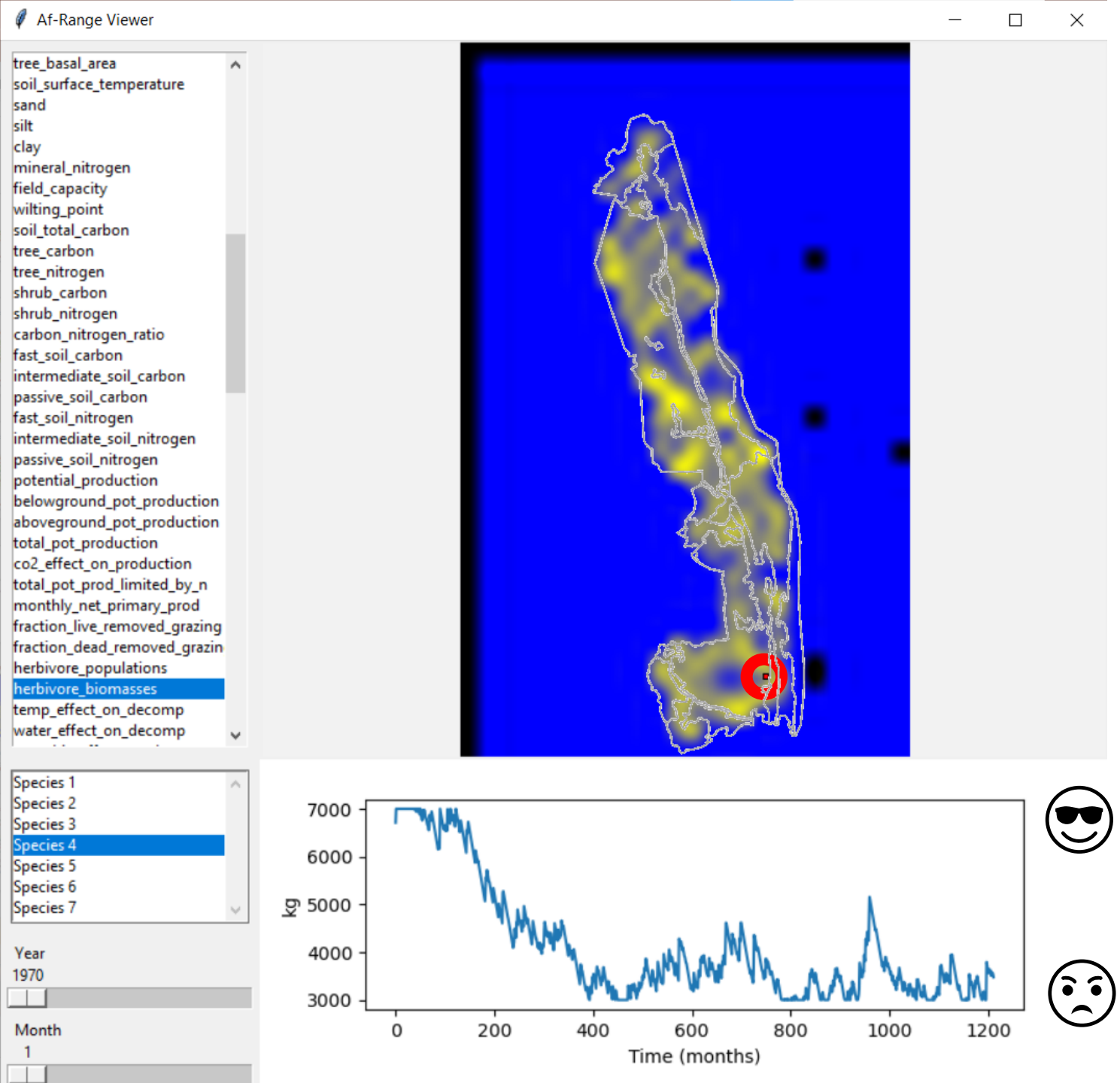
- In Af-Range, every pixel tells a story (*100 years of story…*)

- User tools allow virtual transects for specific location over the entire simulation

137 different variables (for each facet, vegetation, herbivore group …

4 Livestock groups (Cattle, Goats, Sheep, Donkeys)
3 Wildlife (Elephants, ~~Grazers and Mixed Feeders~~)





Virtual Transects of future elephant condition

(shown ACCESS 8.5 25k elephant populations)

Are there spatial differences in elephant condition?

- Granite-based land systems (Ph and Sk) have varied but generally decreased condition (biomass)
- Basalt-based land systems (Le and Sa) have varied condition (biomass)
- Not very sensitive to 25k or 50k elephants
- Not very sensitive to 4.5 or 8.5 climate scenarios

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So how herbivores respond in terms of condition?

- **Wildlife** (**Elephants**, Grazers and Mixed Feeders)
  - Elephants – mixed, positive and negative stories (depending on elephant density and soils)
  - Grazers & Mixed feeders: a ***few positive stories*** *but mostly increased stress from reduced grass biomass and increased shrub biomass & cover*
- **Livestock** (Cattle, Goats, Sheep, Donkeys)
  - Outside the KNP on both sides, ***there are no good stories for livestock…***
  - Consistent and strong negative responses under all climate scenarios

Take Away Messages (so far… T&C's apply)

- Outcomes in the KNP and the greater lowveld are complex and varied
  - Grass- & Tree- dominated areas change locally, but not across larger Granites & Basalt areas
  - Shrub-dominated areas have more varied dynamics, but systematically increase outside the KNP
  - Elephant persistence at high populations have some tradeoffs in terms of condition and impact on woody dominated areas
  - Grazer and Mixed Feeder categories have more consistent decreases in condition

  - Much more change outside of the KNP than inside
    - Cattle and goat condition are significantly decreased over time

- We have (some) options, but are they enough to achieve our goals?
- To channel Bob, what are we trading off? Who pays for our choices?

- *We are happy to train anyone and work with them to develop modeling and analytic capacities.*
- *For more information, contact me at gkiker@ufl.edu or find me at tea/happy hour!*