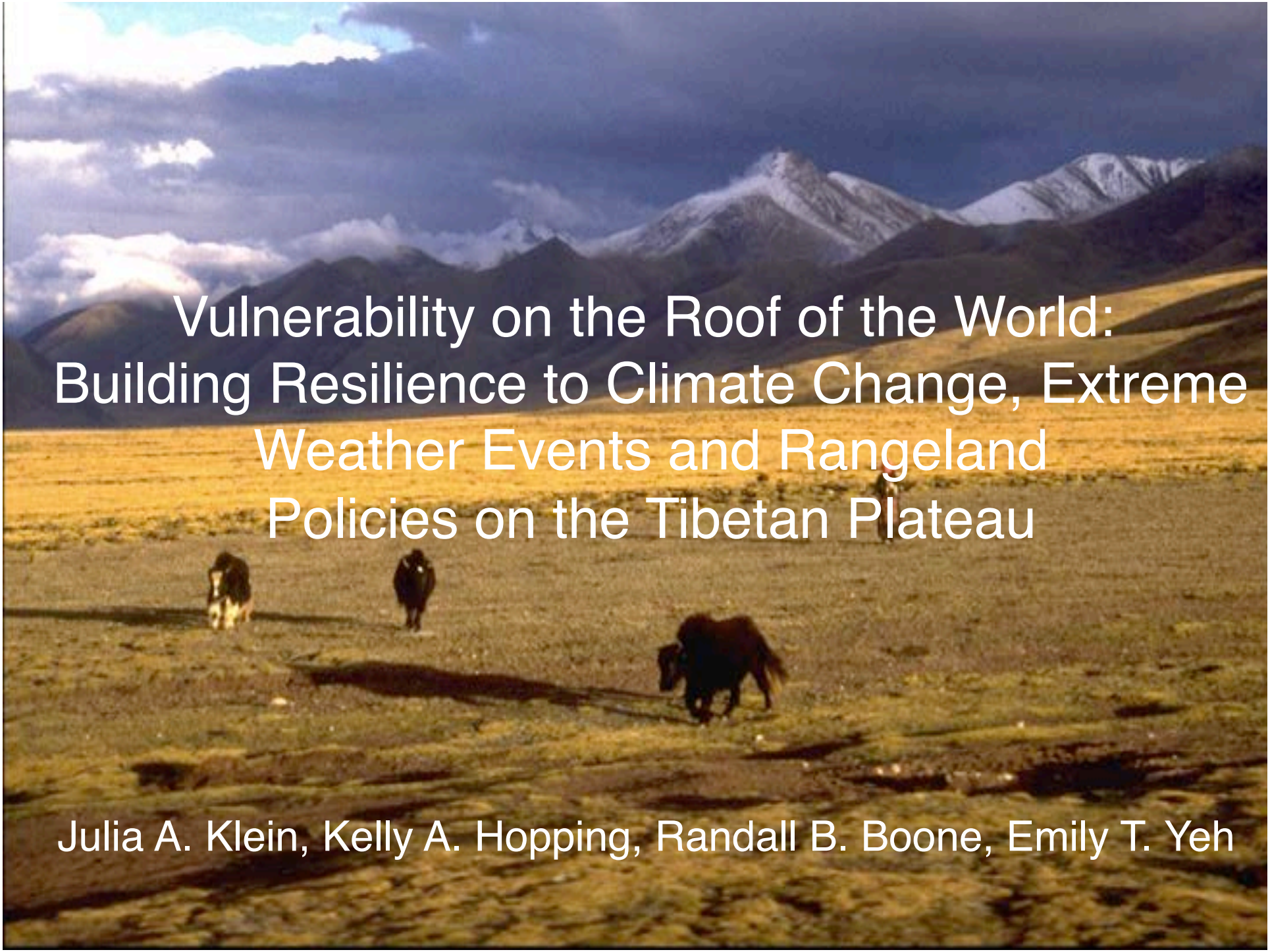
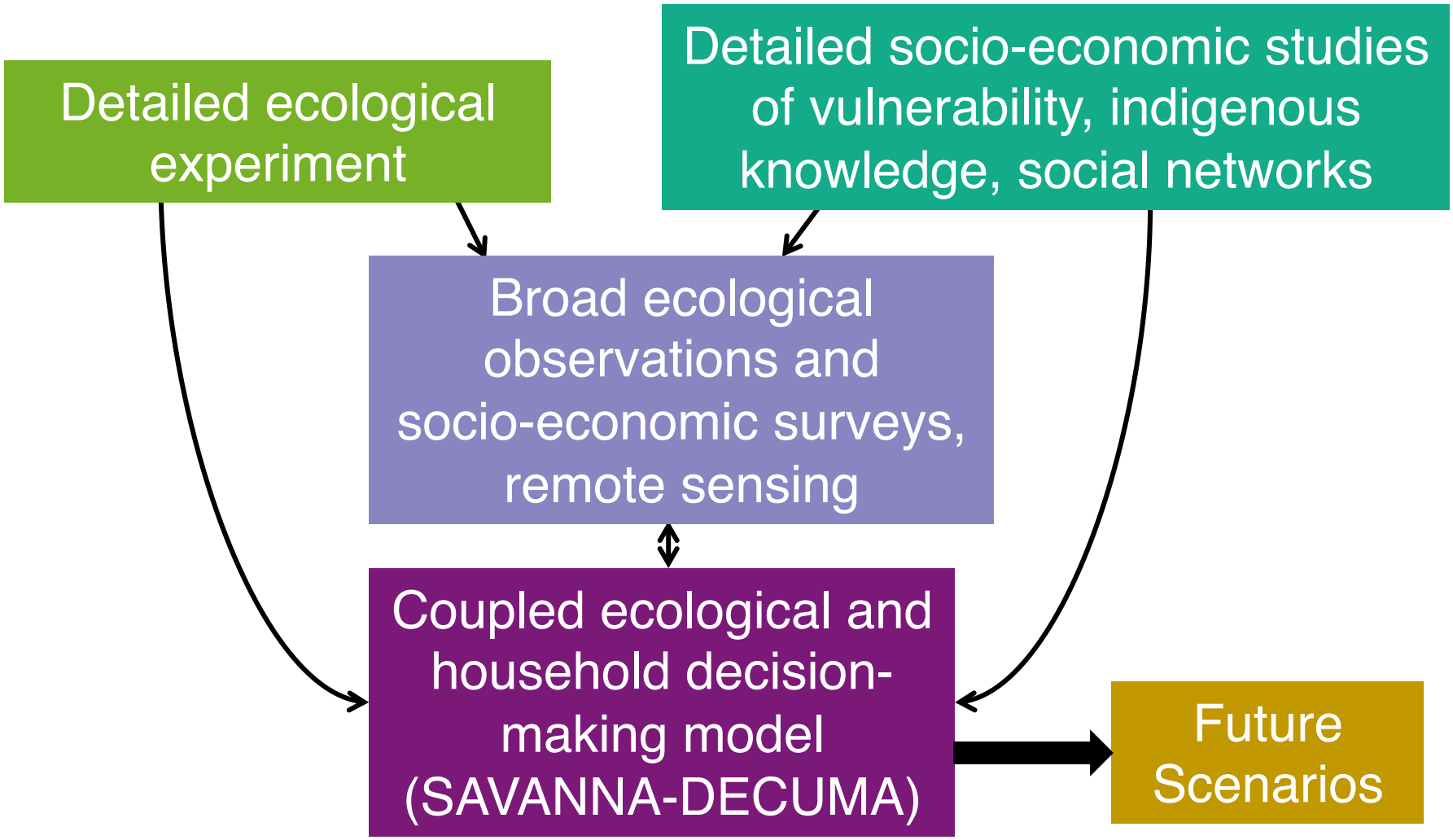


Vulnerability on the Roof of the World: Building Resilience to Climate Change, Extreme Weather Events and Rangeland Policies on the Tibetan Plateau

Julia A. Klein, Kelly A. Hopping, Randall B. Boone, Emily T. Yeh

Multi-method, multi-scaled approach



Main system components

Ecosystem Services

Ecosystem

Alpine rangelands

- Vegetation
- Animals (wild, domestic)
- Glaciers/water
- Soil resources

Social system

Pastoral livelihoods

- Indigenous knowledge
- Cultural practices
- Moral economy
- Political economy
- Traditional institutions

Decisions & Actions

Ecosystem Services

Local

- Forage
- Medicinal plants/animals
- Livestock products (livelihoods)
- Wildlife
- Tourism opportunities
- Knowledge & Stewardship
- Aesthetic & Cultural value
- Local & downstream water supply
- Carbon sequestration & storage
- Climate regulation

Global

External Drivers, Shocks, Stressors

Climate

Drivers

- Temperature
  - Warming
- Precipitation

Shocks

- Extreme weather
  - Severe snowstorms

Ecosystem

Alpine grasslands

Social system

Pastoral livelihoods

External Drivers, Shocks, Stressors

Climate

Drivers

- Temperature
  - Warming
- Precipitation

Shocks

- Extreme weather
  - Severe snowstorms

Ecosystem

Alpine grasslands

Social system

Pastoral livelihoods

Policies

- Fencing
- Privatization
- Sedentarization
- Herd limits
- Grazing bans
- Restocking

External Drivers, Shocks, Stressors

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Economy

- Market integration
- ↑ need for cash income
- Tourism

External Drivers, Shocks, Stressors

Climate

- Warming temperatures
- Severe snowstorms

Ecology

- Δ Species composition
- Δ Glaciers
- Δ Wildlife populations
  - grazers (pikas)
  - predators
- Δ Pests
  - toxic plants
  - parasites

Internal Dynamics and Stressors

Policies

- Fencing
- Herd limits
- Grazing bans
- Restocking

Economy

- Market integration
- Tourism
- Pressure for cash income

External Drivers, Shocks, Stressors

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Infrastructure

- Houses
- Radio
- Vehicles
- Fences
- Roads
- Cell phones

Internal Dynamics and Stressors

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Infrastructure

- Houses
- Radio
- Vehicles
- Fences
- Roads
- Cell phones

Institutions

- Land tenure
- Village committees
- Private lending/credit

Economy

- Market integration
- Tourism
- Pressure for cash income

Internal Dynamics and Stressors

System features that confer resilience

Drivers & Shocks

- Climate change
- Policies
- Economic pressure

Exposure

Sensitivity:

- ecosystem
- grazing resources

Adaptive capacity:

- diversity (*species, livelihoods, knowledge*)
- leadership
- innovation
- social capital
- legal/political rights

Vulnerability

Chapin *et al.* 2009

System features that confer resilience

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- social capital
- legal/political rights

Vulnerability

Constraints on traditional coping and adaptation strategies

- Reduced :
  - mobility
  - herd sizes
  - ecosystem health

Chapin *et al.* 2009

System features that confer resilience

Drivers & Shocks

- Climate change
- Policies
- Economic pressure

Exposure

Sensitivity:

- ecosystem
- grazing resources

Adaptive capacity:

- diversity (*species, livelihoods, knowledge*)
- leadership
- innovation
- social capital
- legal/political rights

- Persistence:
  - Traditional livelihood practices, herding
  - Healthy ecosystems
- Navigated transformation:
  - Alternative livelihoods
- Unintended transformation:
  - Ecosystem degradation
  - Flooded grazing land
  - Shift from cooperative to privatized grazing mentality

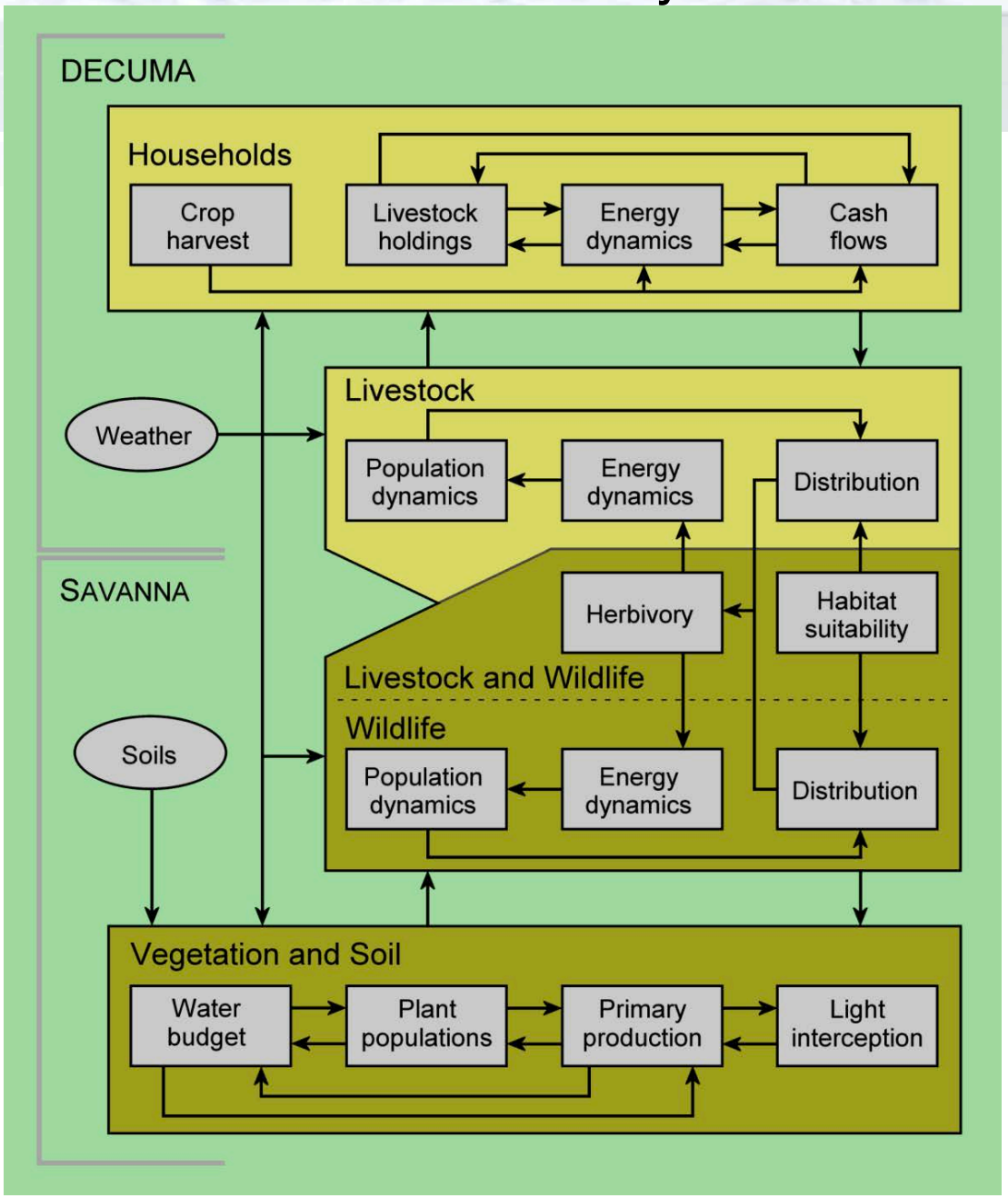
Vulnerability

Resilience

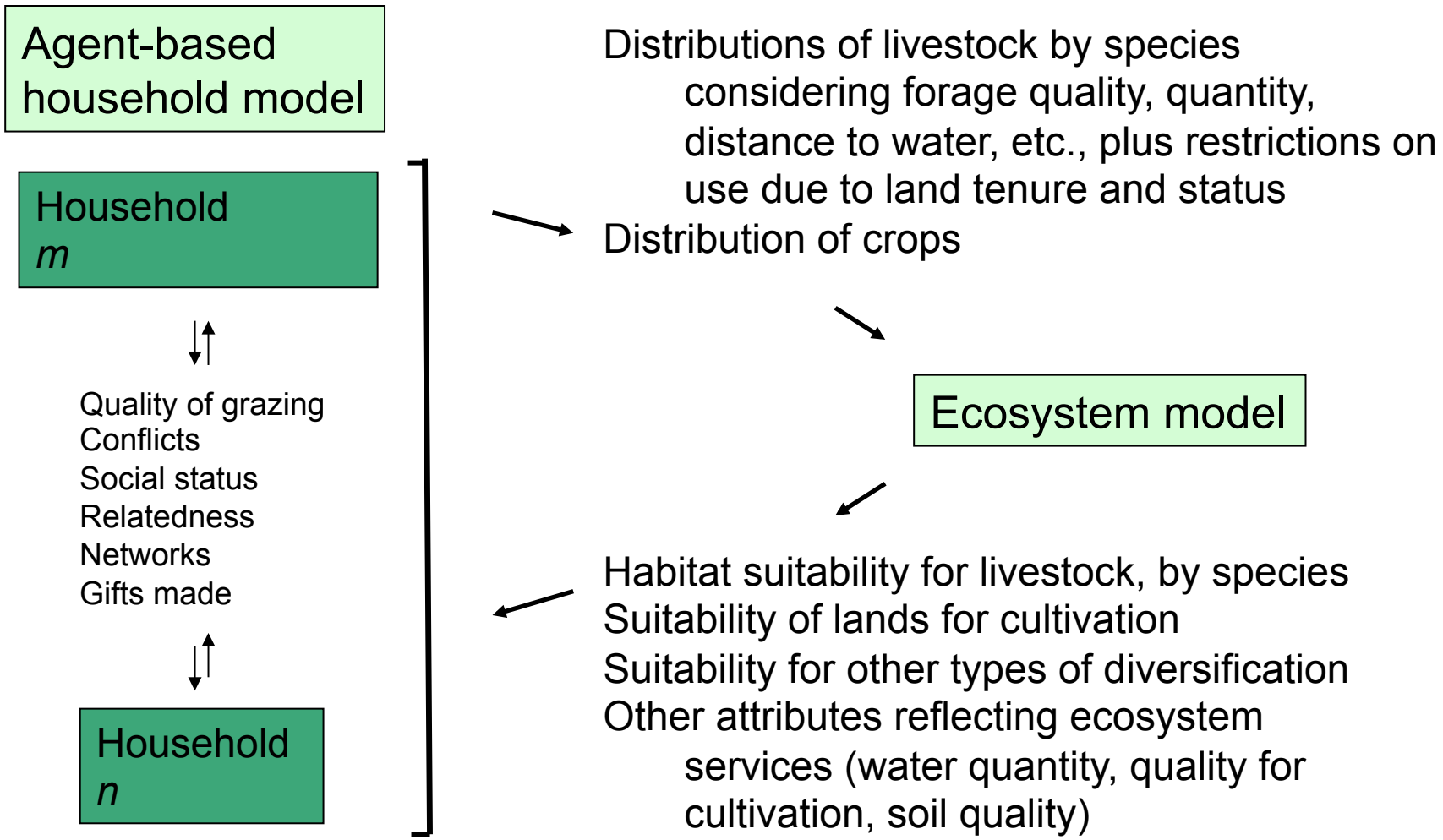
Chapin *et al.* 2009

Modeling a Coupled Natural and Human System

The linked SAVANNA and DECUMA models



Agent-based Household Decision Making



Example spatial distributions in DECUMA

Mean Response variables In DECUMA

Out
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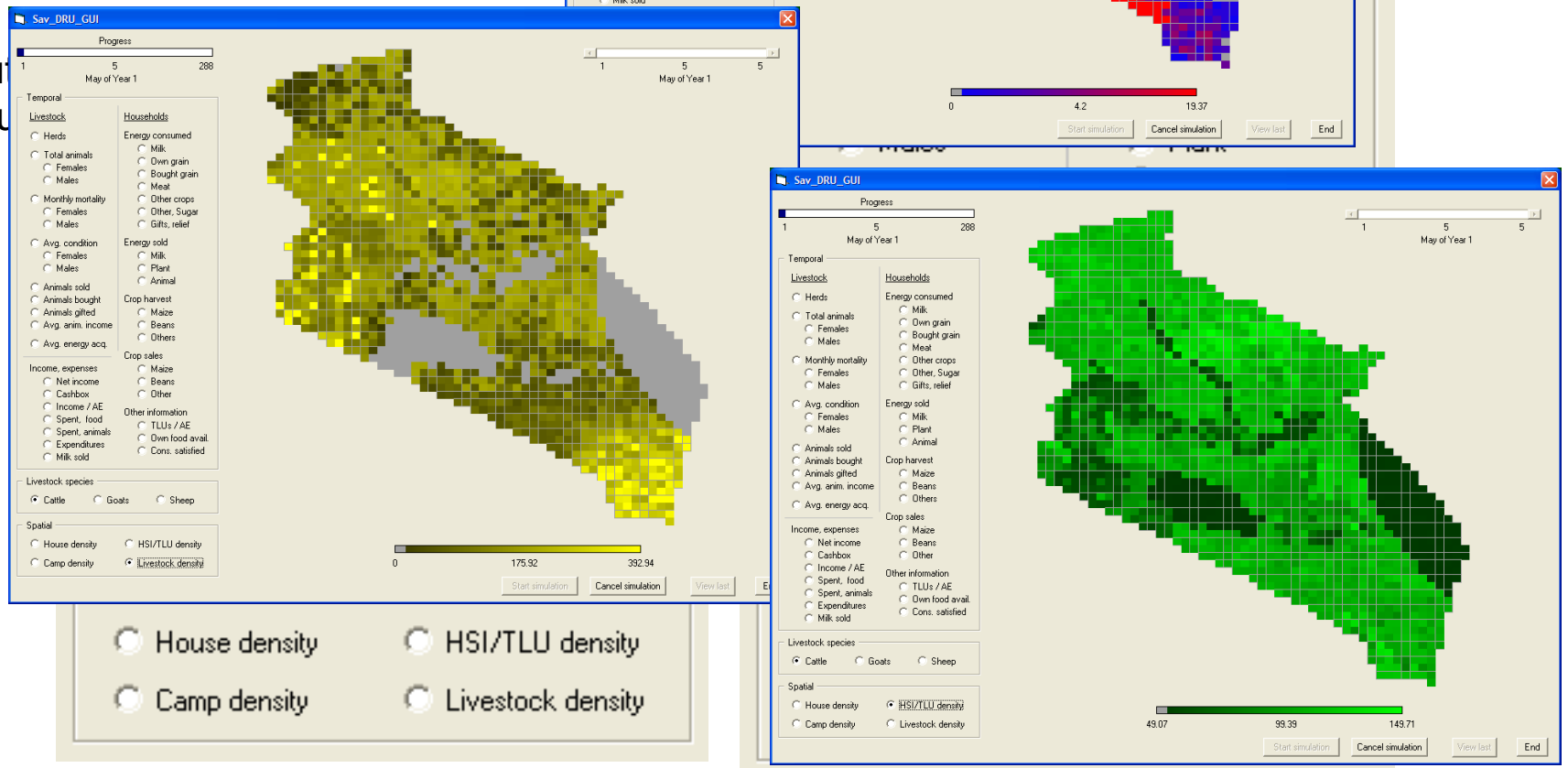
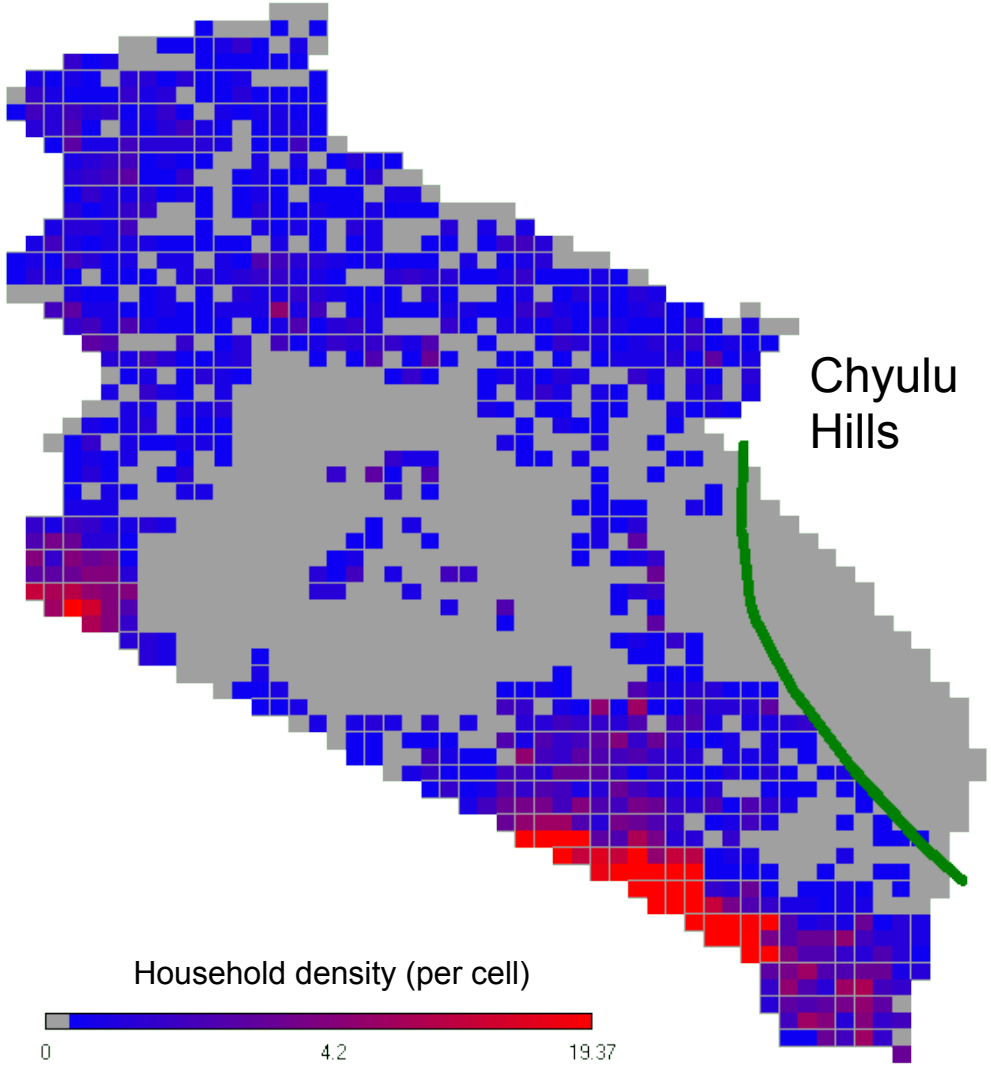


The Value of a Grazing Reserve

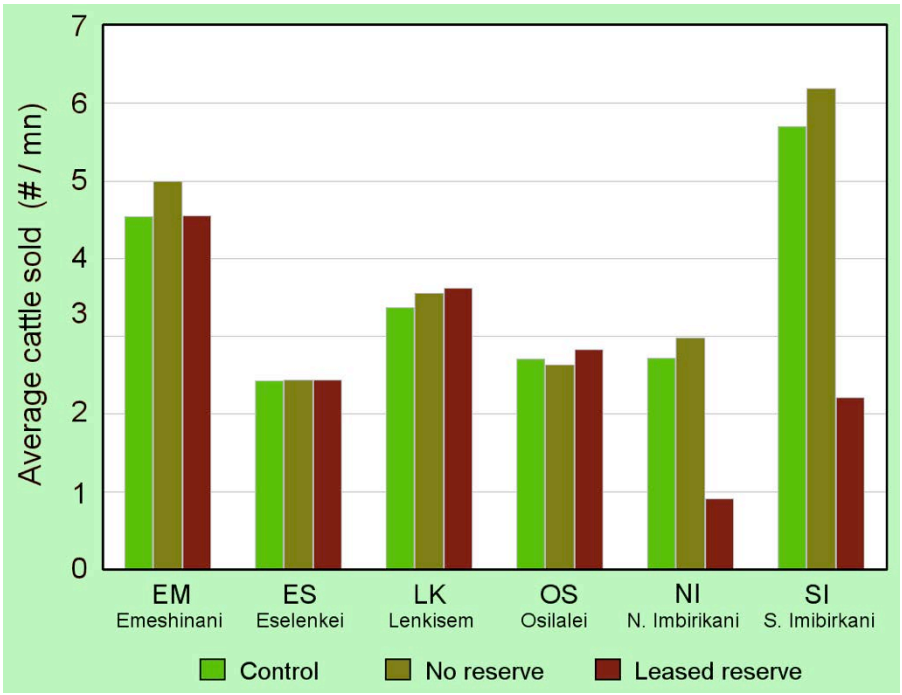
Chyulu Hills are treated as a grazing reserve, with little use until the dry season (i.e., August-October).

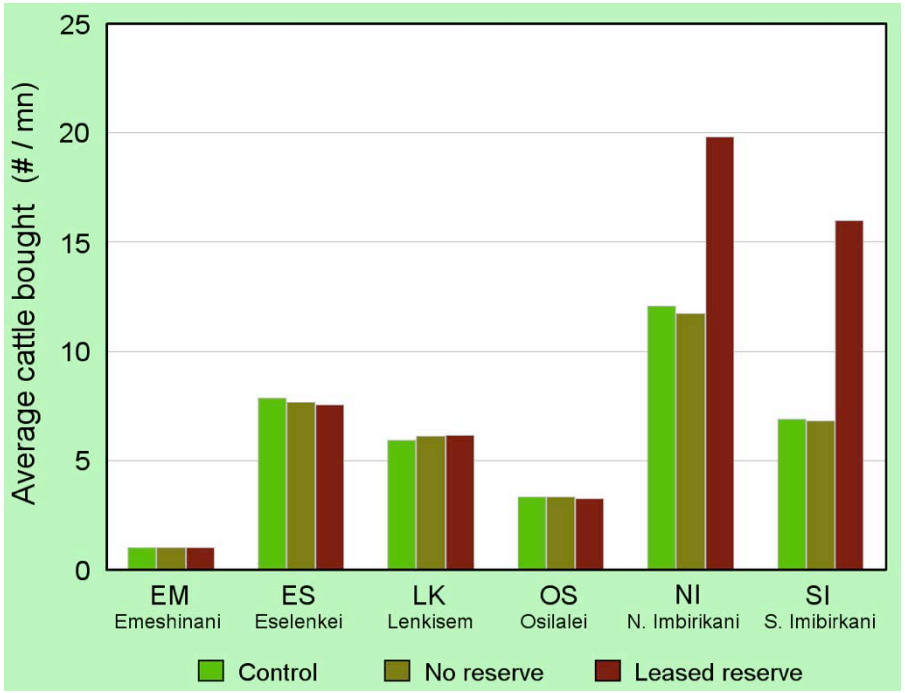
Chyulu Hills have been discussed as an area for rain-fed agriculture.

If the Chyulus were unavailable to mobile Maasai herders and their livestock, what would be the effects on populations?

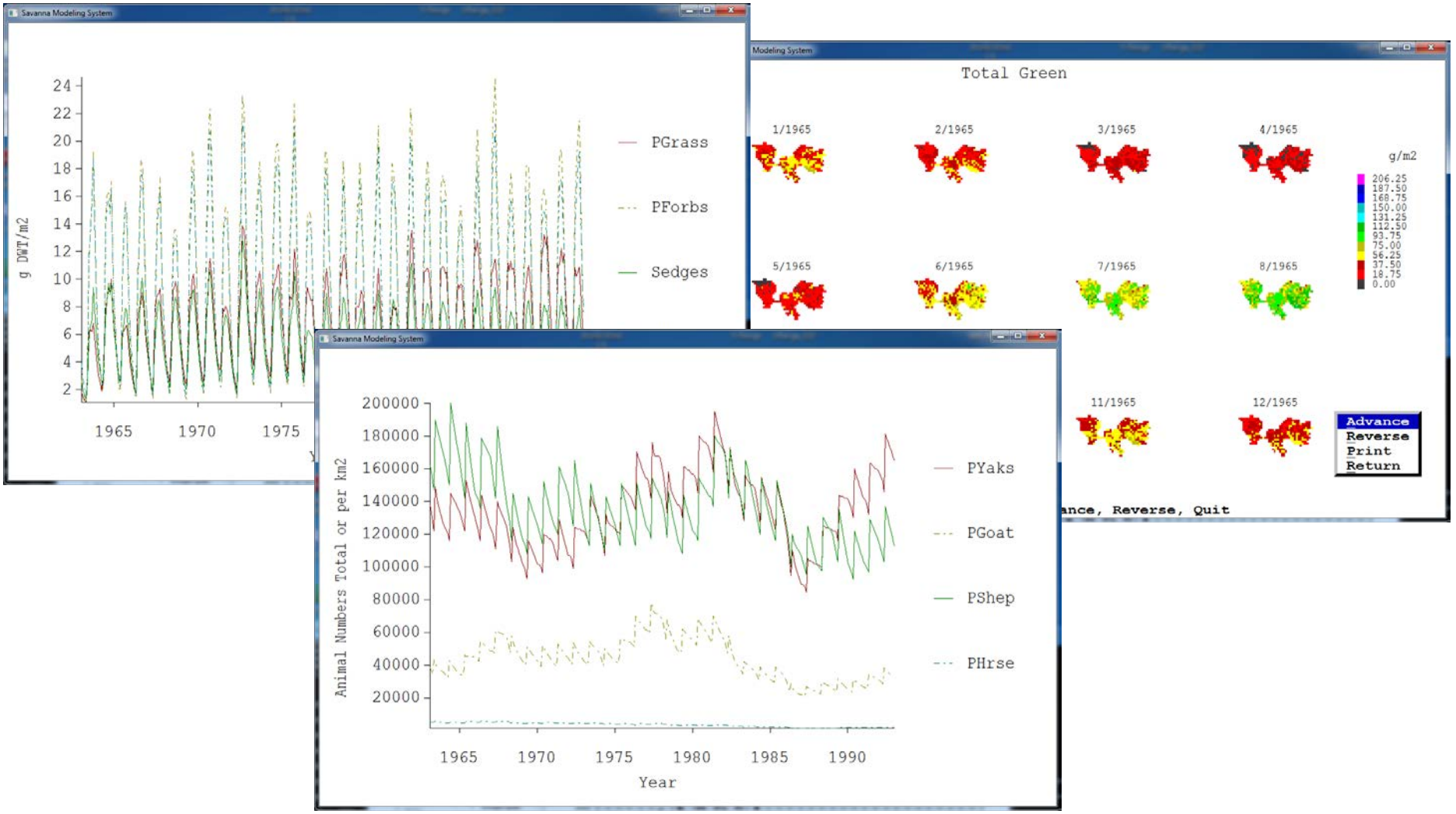


The Value of a Grazing Reserve





Progress on Tibetan Application



Some Policy Questions that may be addressed with DECUMA & SAVANNA

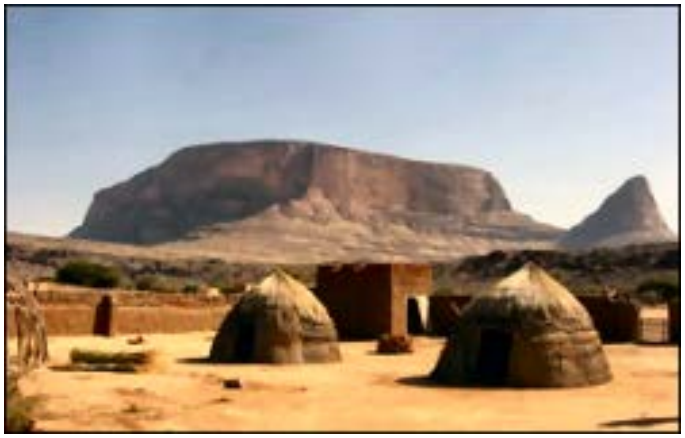
- Climate change and drought responses
- Changes in herbivore access
- Livestock stocking rates
- Livestock survival through veterinary care
- Changes in water supplies
- Effects of cultivation
- Effects of human population growth
- Land tenure changes and subdivision

An Example Suite of Scenarios

In Samburu, Kenya, we are addressing:

- Changes in animal health associated with changes in veterinary care
- Effects of subdivision on livestock capacity and pastoralist wellbeing
- Commercial cropping in Siambu and fencing in Mbaringon
- Increased livestock use during drought
- Tradeoffs between support for livestock and support for wildlife in Mbaringon
- Enhanced goat breeds and milk production
- Effects of increased crop yields on pastoralist wellbeing

Other Approaches and Tools

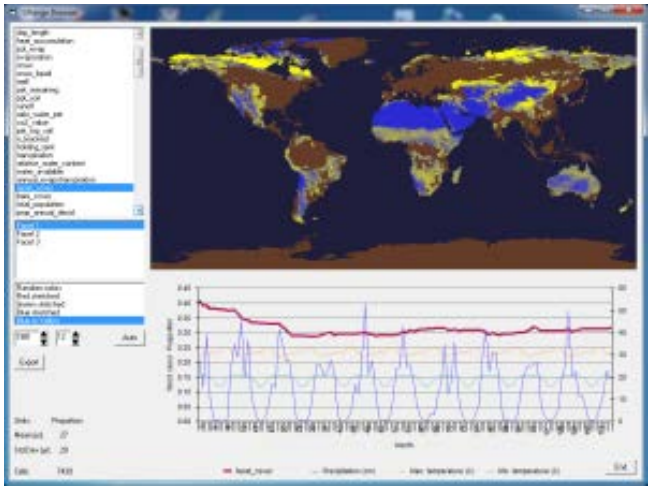


DECUMA is weakly linked to the ecosystem model, and may be joined with many different models

In an NSF-supported project in Mali, we are using DECUMA with the African Carbon Exchange (ACE) model and the Soil and Water Assessment Tool (SWAT) to understand how pastoralists and hydrology are linked

In an effort supported by the International Livestock Research Institute, we have constructed a global ecosystem model of moderate complexity called G-Range.

G-Range may be used to look at mountain habitats across the globe simultaneously



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