Utility of Model Applications for Adaptive Management Planning for Climate Change

Climate Change in the Northeast: Preparing for the Future

U Mass, Amherst
June 2008

Dennis Ojima
Robert Corell
(ojima@heinzctr.org)

THE HEINZ CENTER

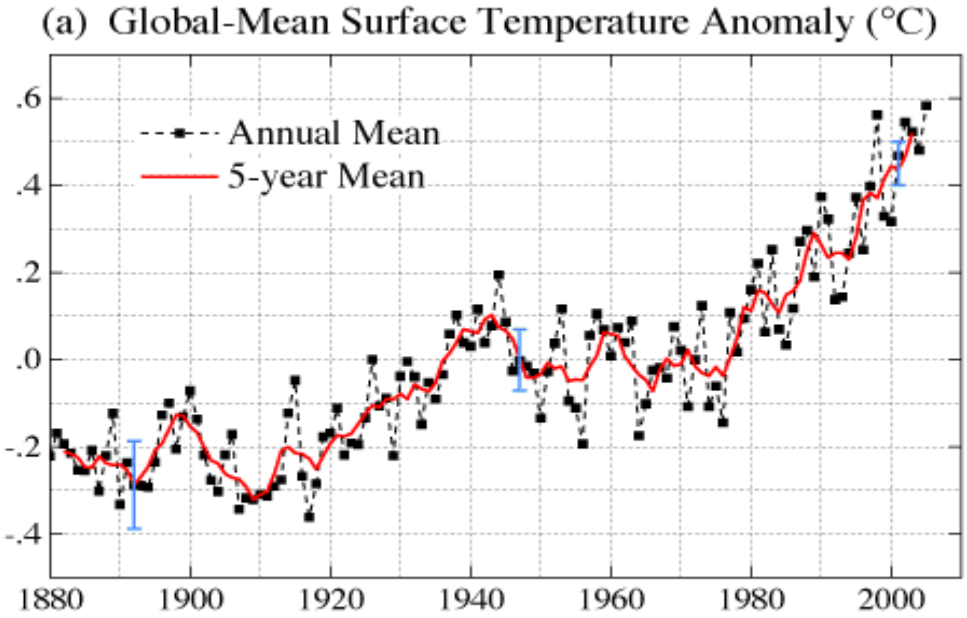
THE H. JOHN HEINZ III CENTER FOR SCIENCE, ECONOMICS AND THE ENVIRONMENT

CONTRIBUTORS

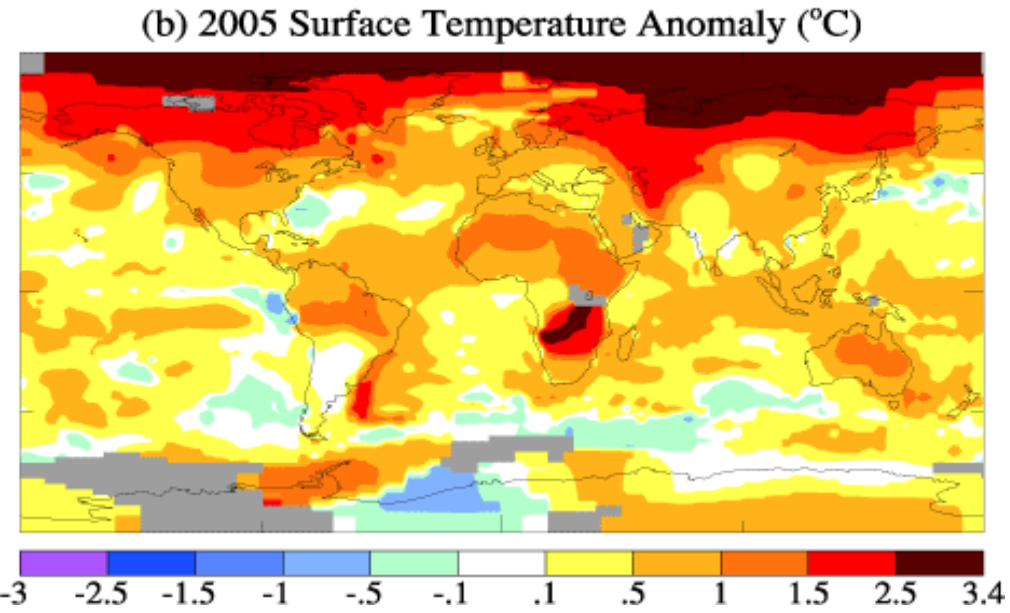
- Dominique Bachelet (TNC), Jill Baron (USGS), Kathy Galvin (CSU/NREL&Anthro), Melannie Hartman (CSU/NREL), Jesse Logan (formerly USFS)

OUTLINE

- Global Climate Change and Impacts
- Issues on Ecological Forecasting and Ecosystem Adaptive Management
- Modeling and Decision Making



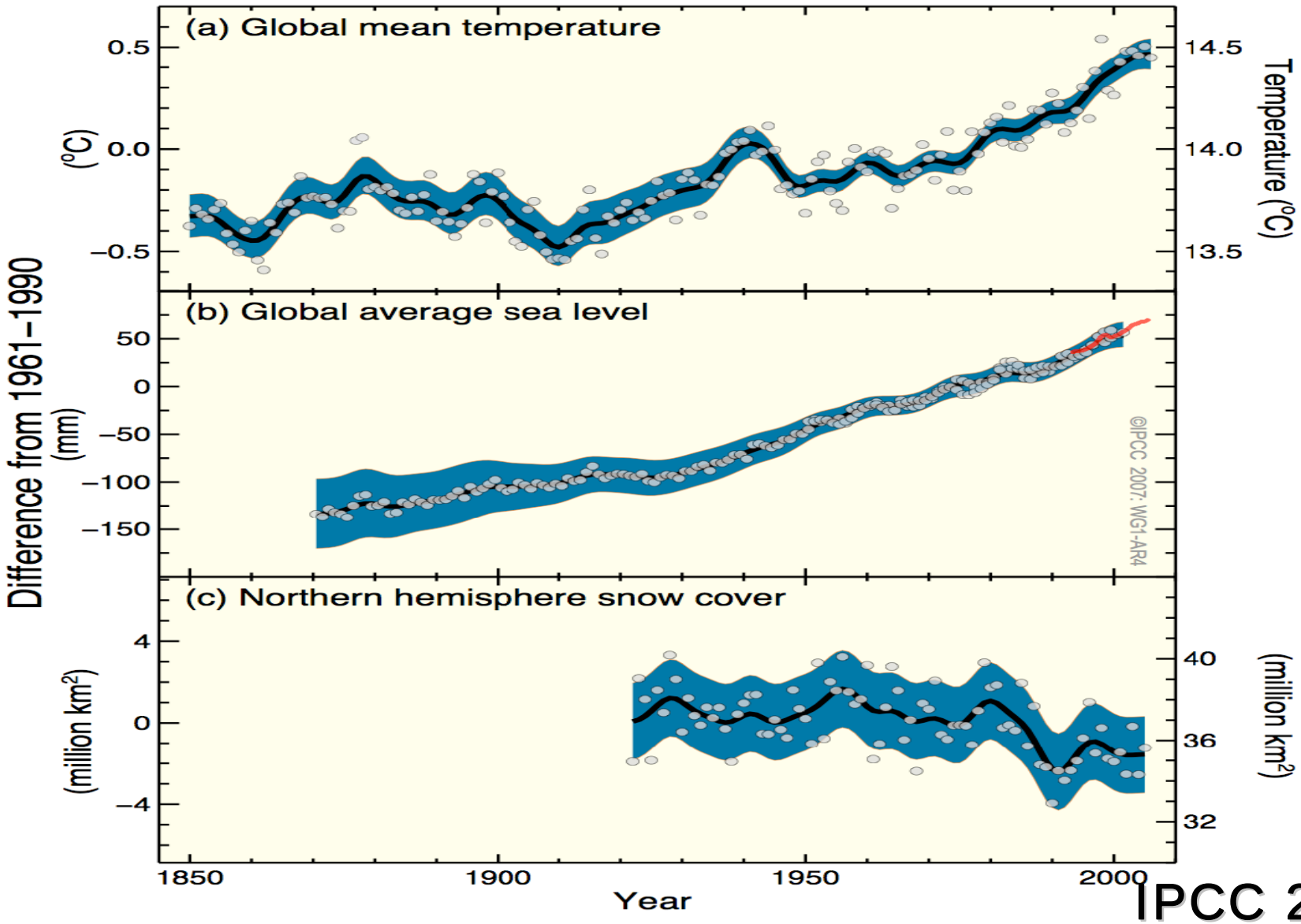
Warming greatest at high latitudes



- **5 warmest years: 1998, 2002, 2003, 2004, 2005**

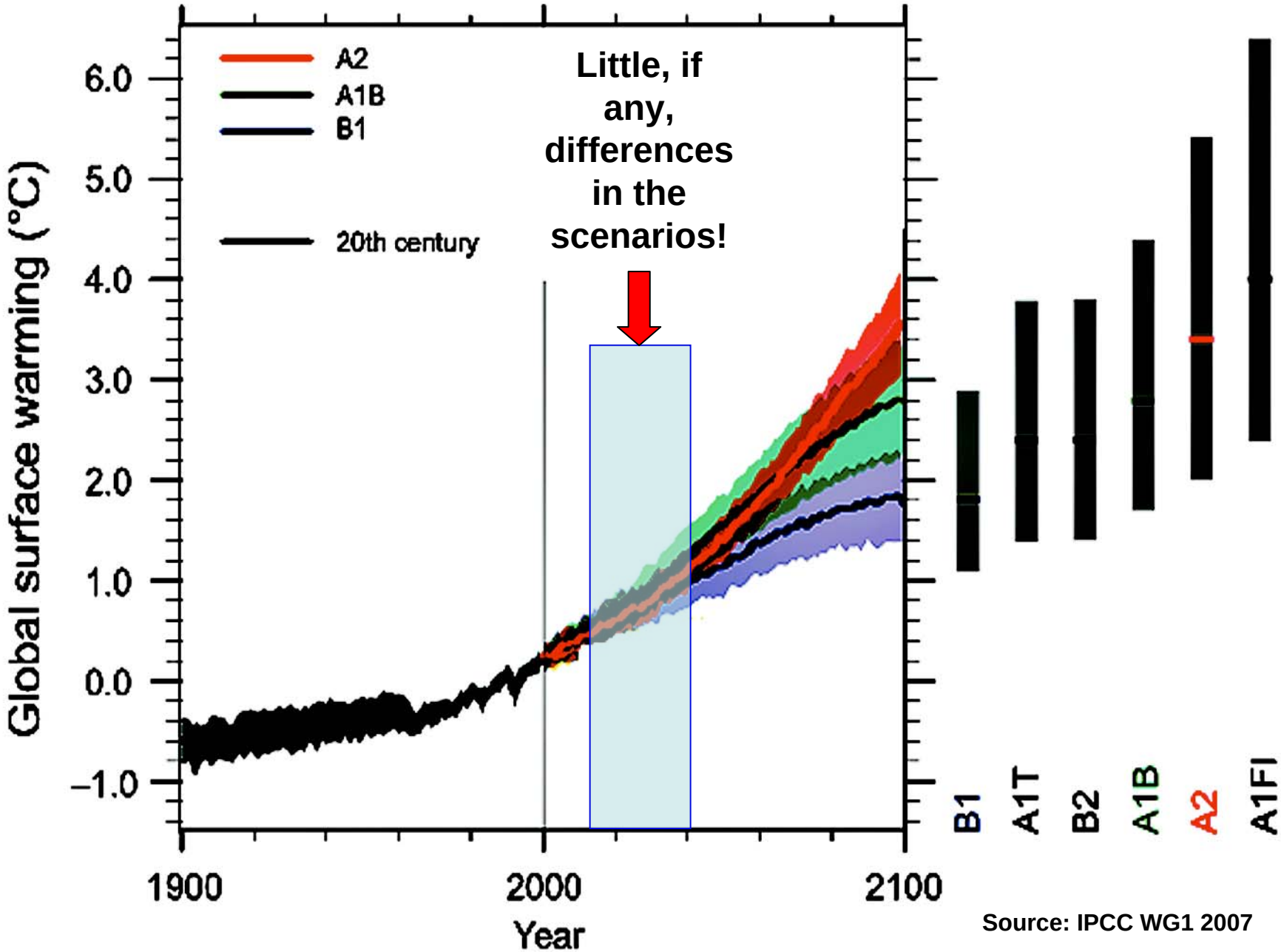
- **Amplification of warming due to decrease of albedo (melting of snow and ice)**

Changes in Temperature , Sea Level and Northern Hemisphere Snow Cover



IPCC 2007

Multi-model Averages and Assessed Ranges for Surface Warming



Source: IPCC WG1 2007

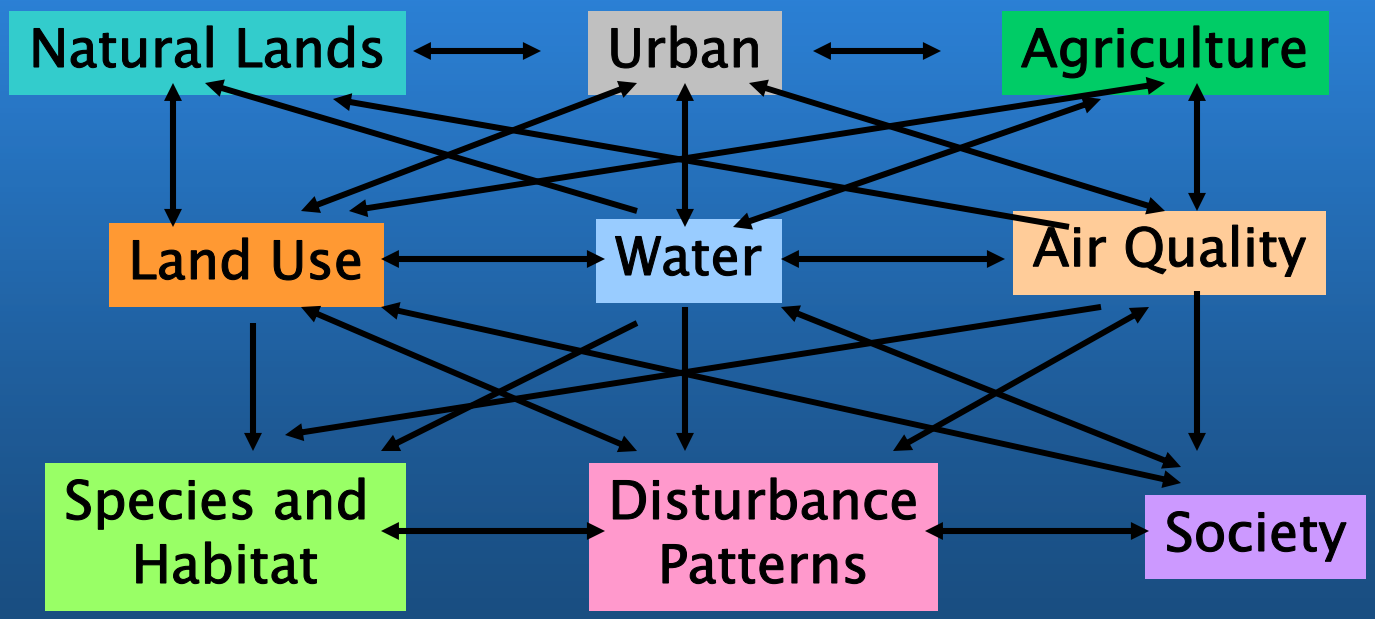
ISSUES

- Multiple Stresses
- Multiple Scales of Space-Time-Biota (Global to Genes)
- Well Tested Modeling Frameworks
- Complex Adaptive Systems of the Coupled Human-Environmental System

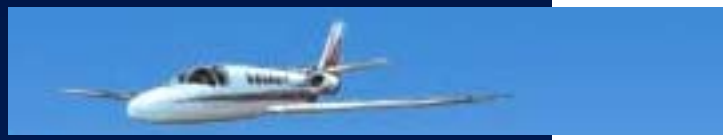
Multiple Forcings

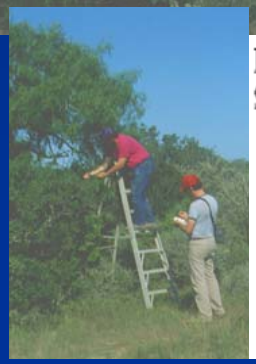
Water Demand | Market | Demographics | Energy | Climate | Policy

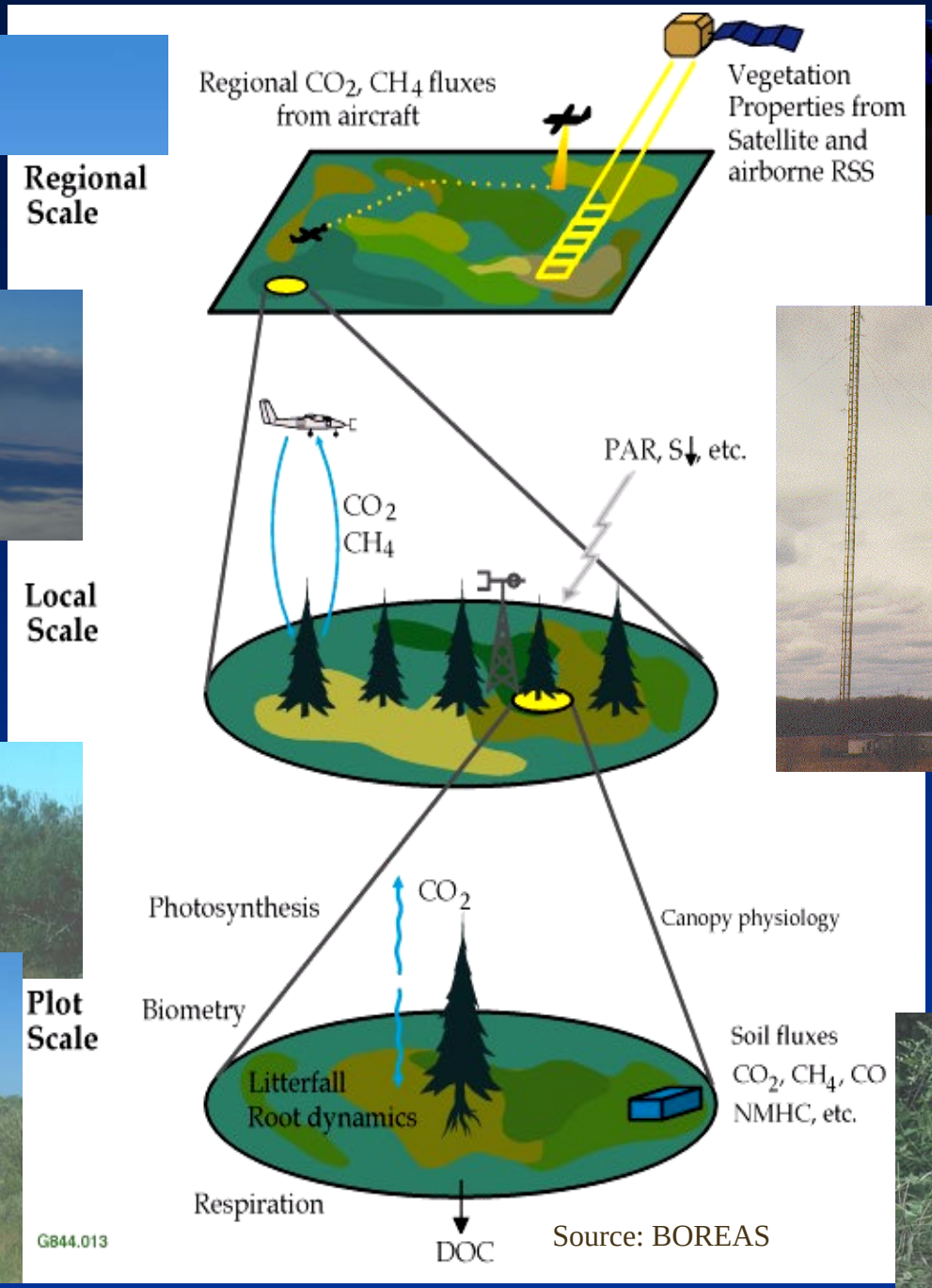
Cascading Effects



(Jill Baron)



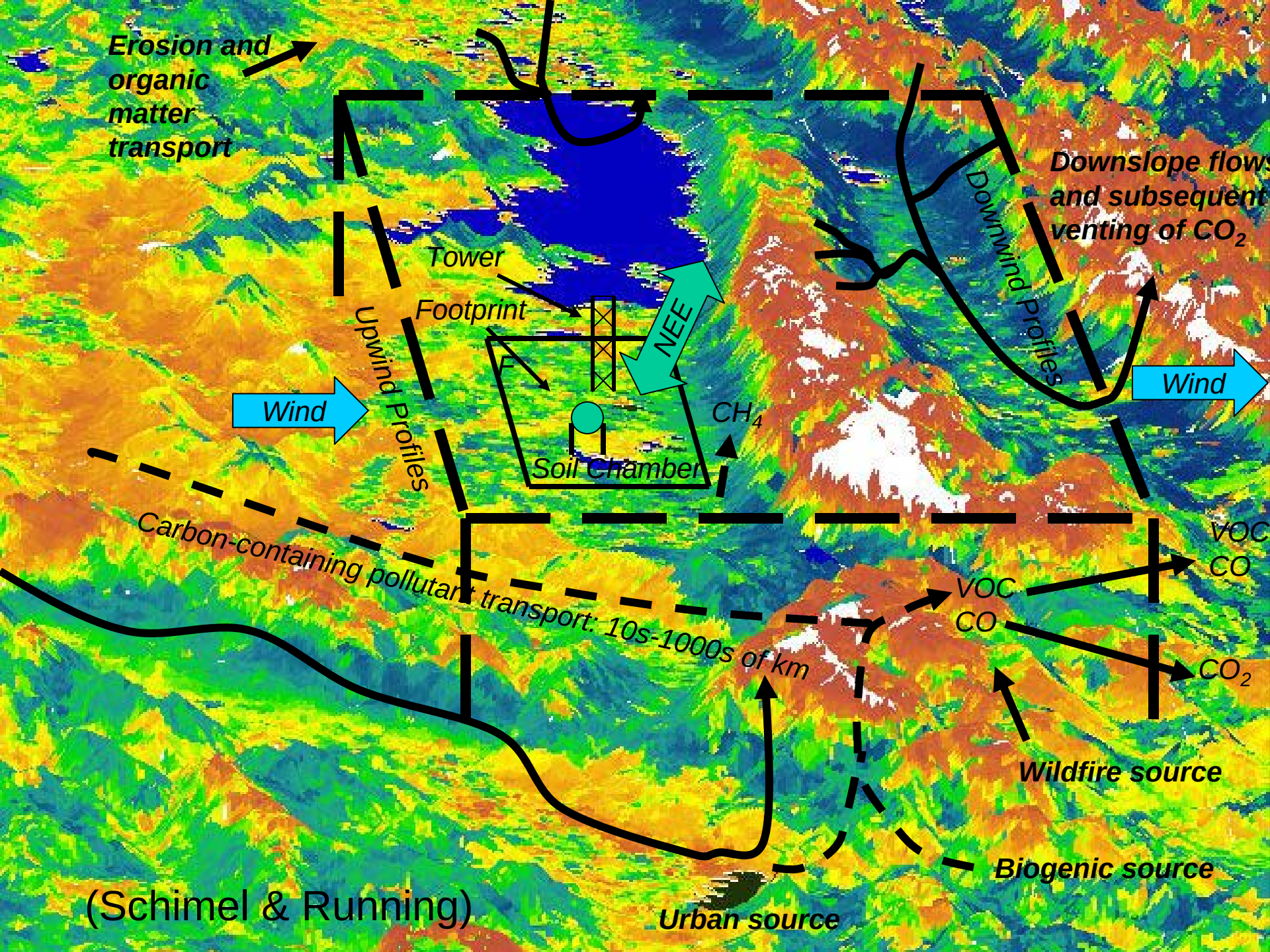




Source: BOREAS

Role of Modeling

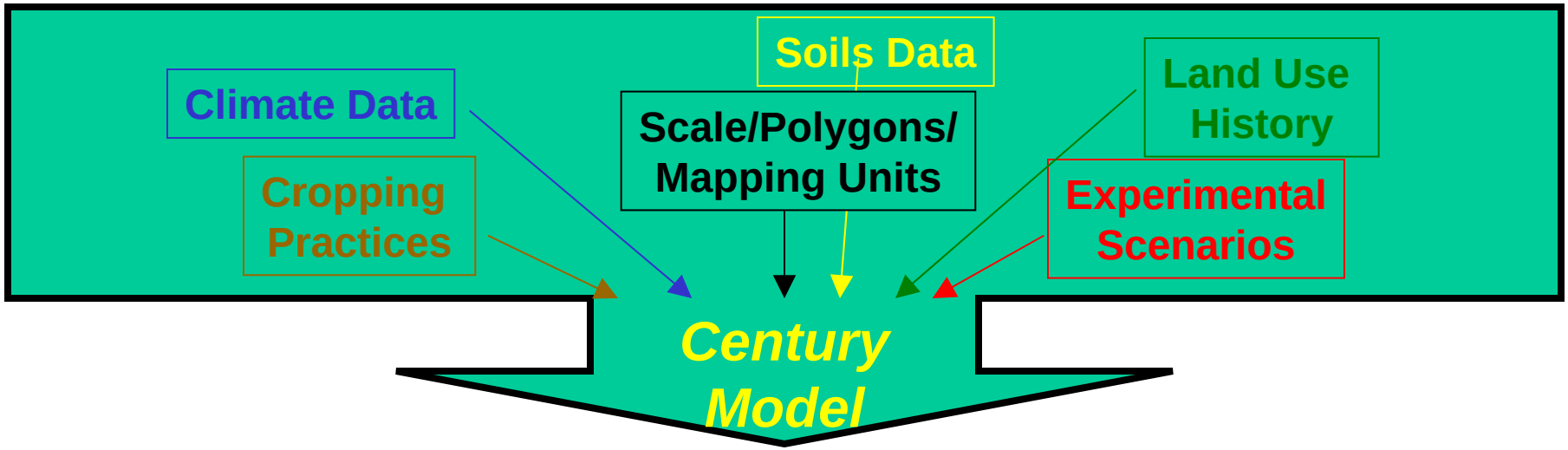
- Climate Inputs
- System Analysis
- Decision Support
- Scenario Framing



(Schimel & Running)

Data Integration for Modeling Ecosystem Dynamics of Managed Lands

- Heterogeneity of soils within mapping units
- Complex land system histories, disturbance and management
- Strict Input format requirements



Ecosystem Dynamics and Structure

DAYCENT: Primary Inputs/Outputs

Climate
- Daily Precipitation
- " Max/Min Temperature

Soil Properties
- Texture
- Bulk Density
- FC, WP, K_{sat}

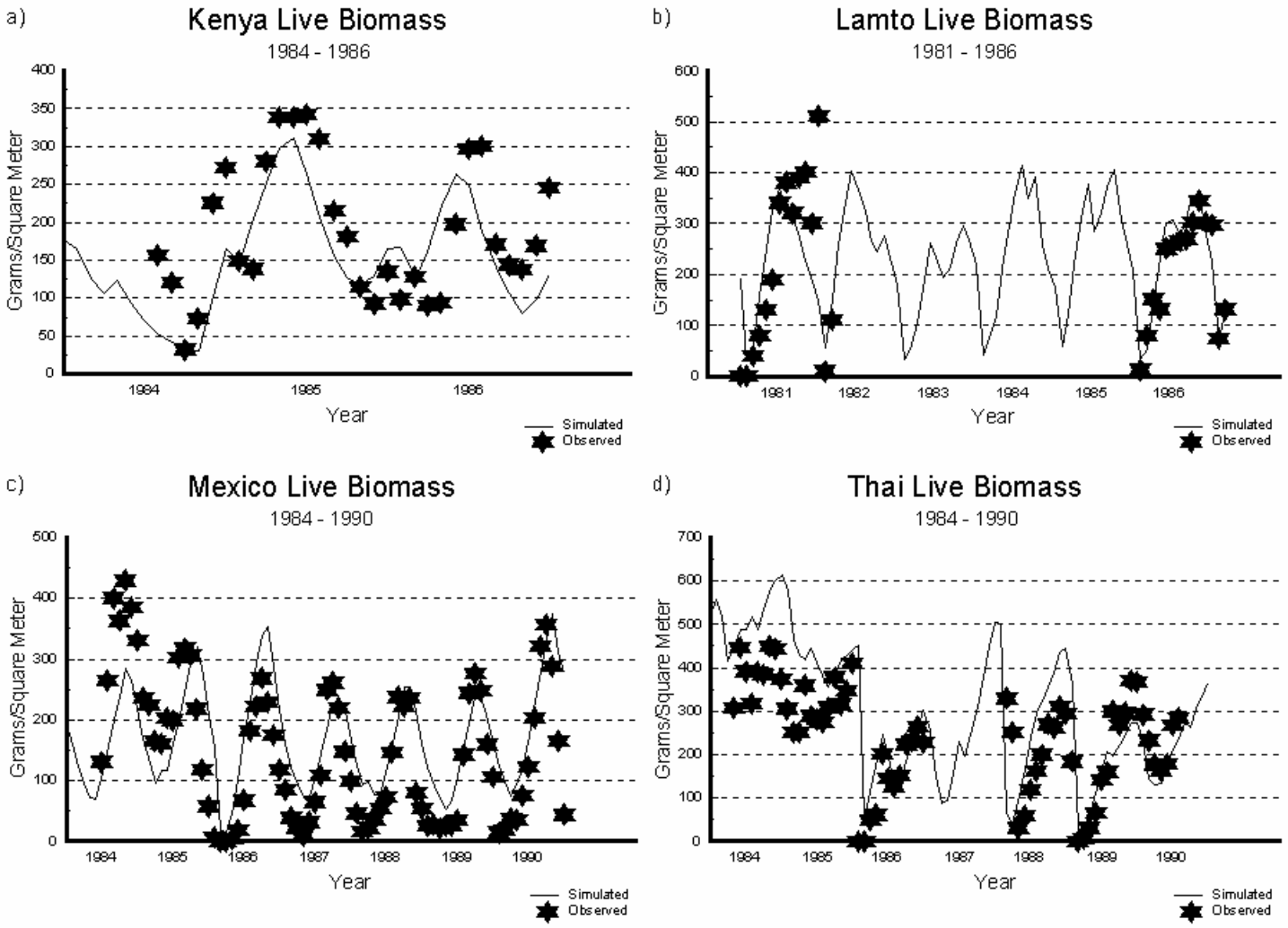
Land Use
- Vegetation Type
- Nutrient, H_2O Inputs
- Tillage/Harvest
- Grazing/Burning

DAYCENT MODEL

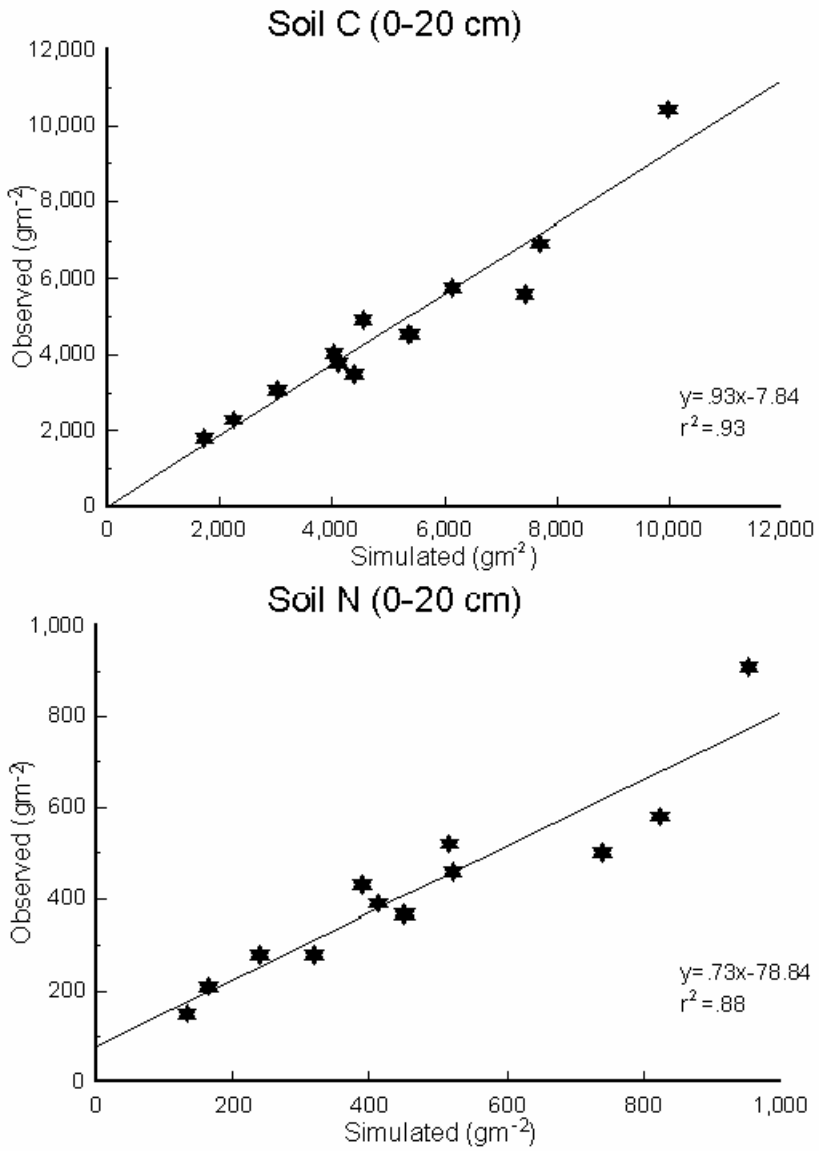
Plant Production
- NPP Allocation
- Grain Yields

SOM Changes
- active/slow/recalcitrant pools

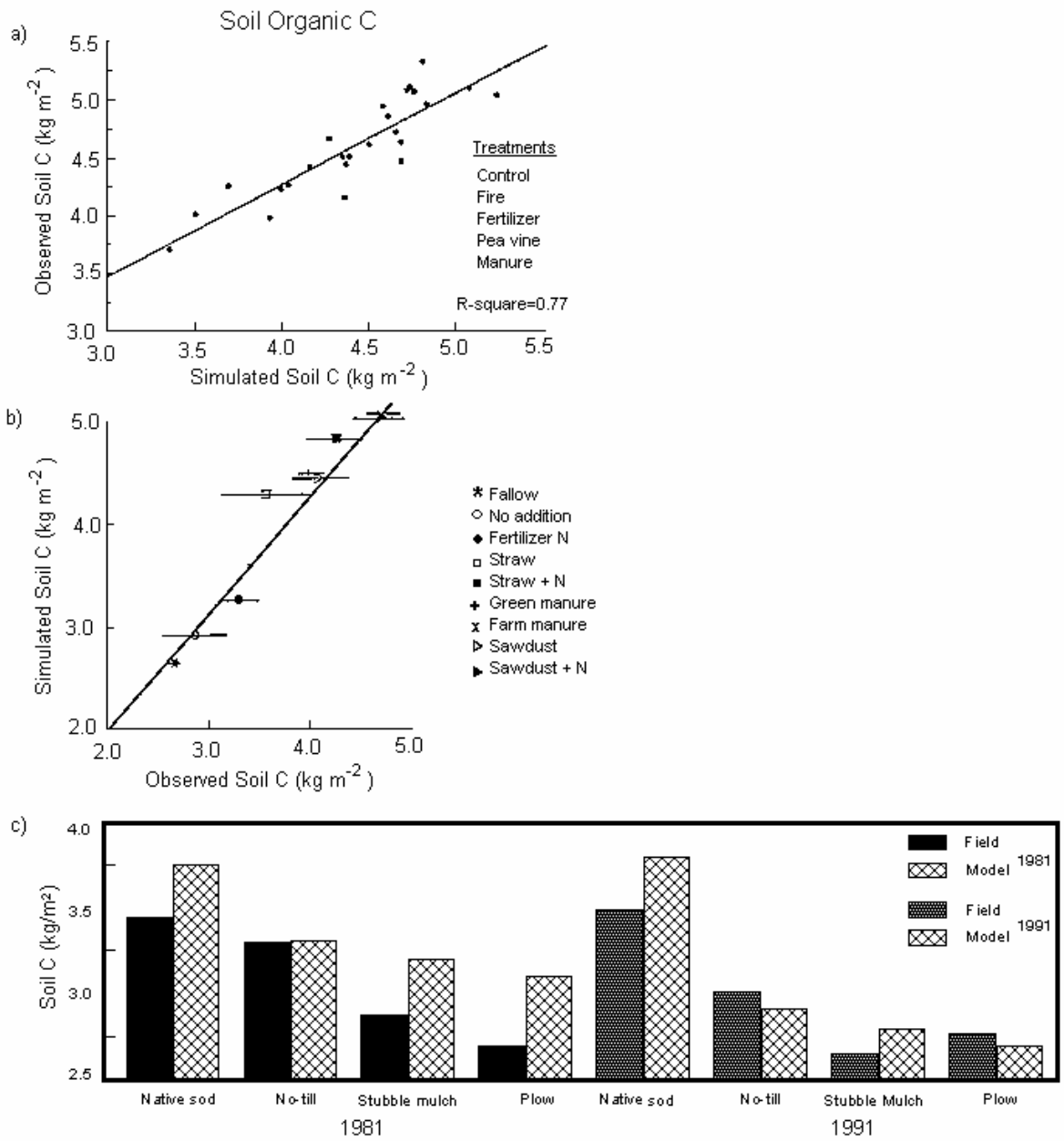
Trace Gas Fluxes
- CO_2, CH_4
- N_2O, NO_X



Comparison of simulated and observed live biomass for (a) Kenya, (b) Lamto, (c) Mexico, and (d) Thailand sites.

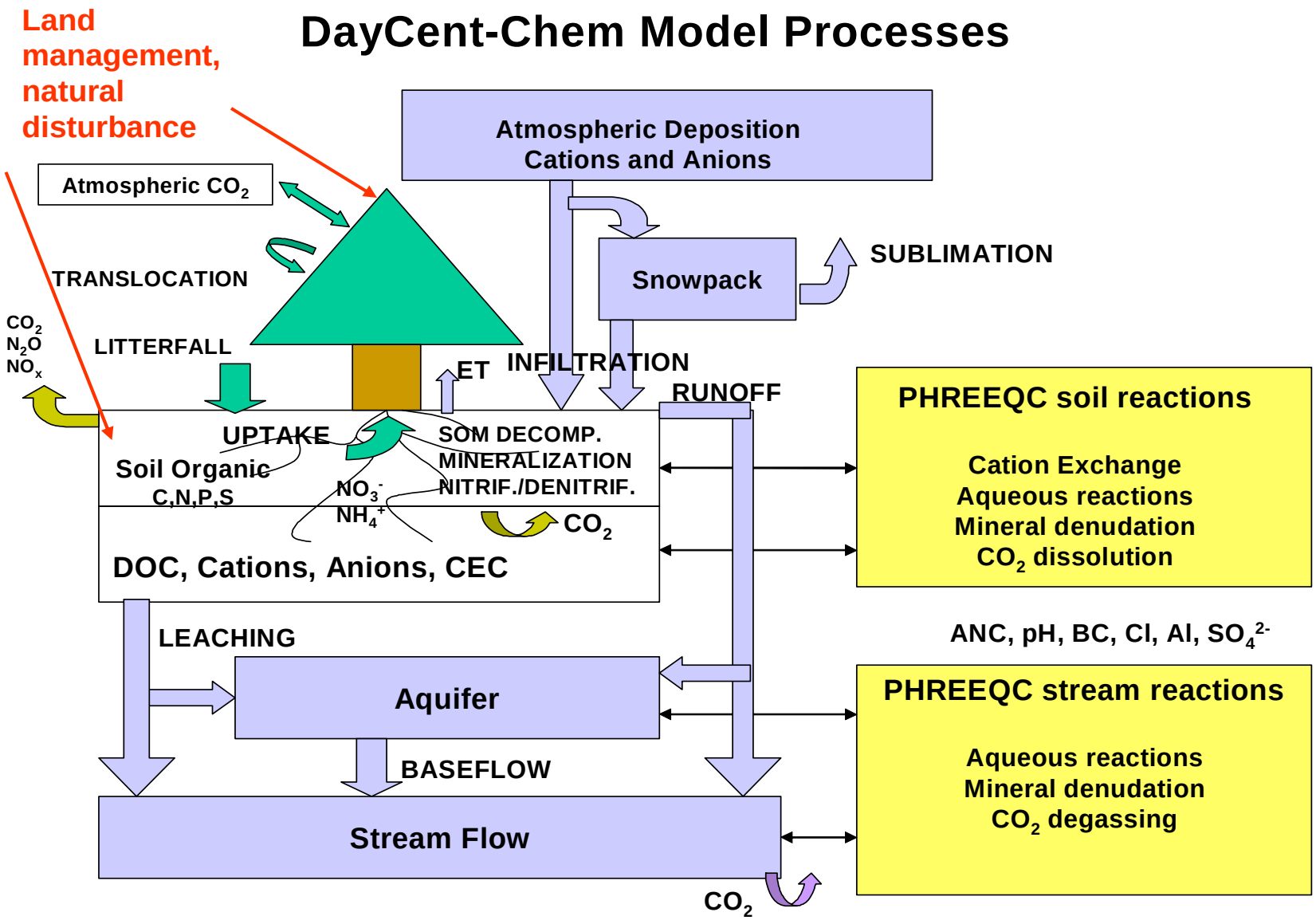


Comparison of simulated and observed soil (a) C and (b) N.

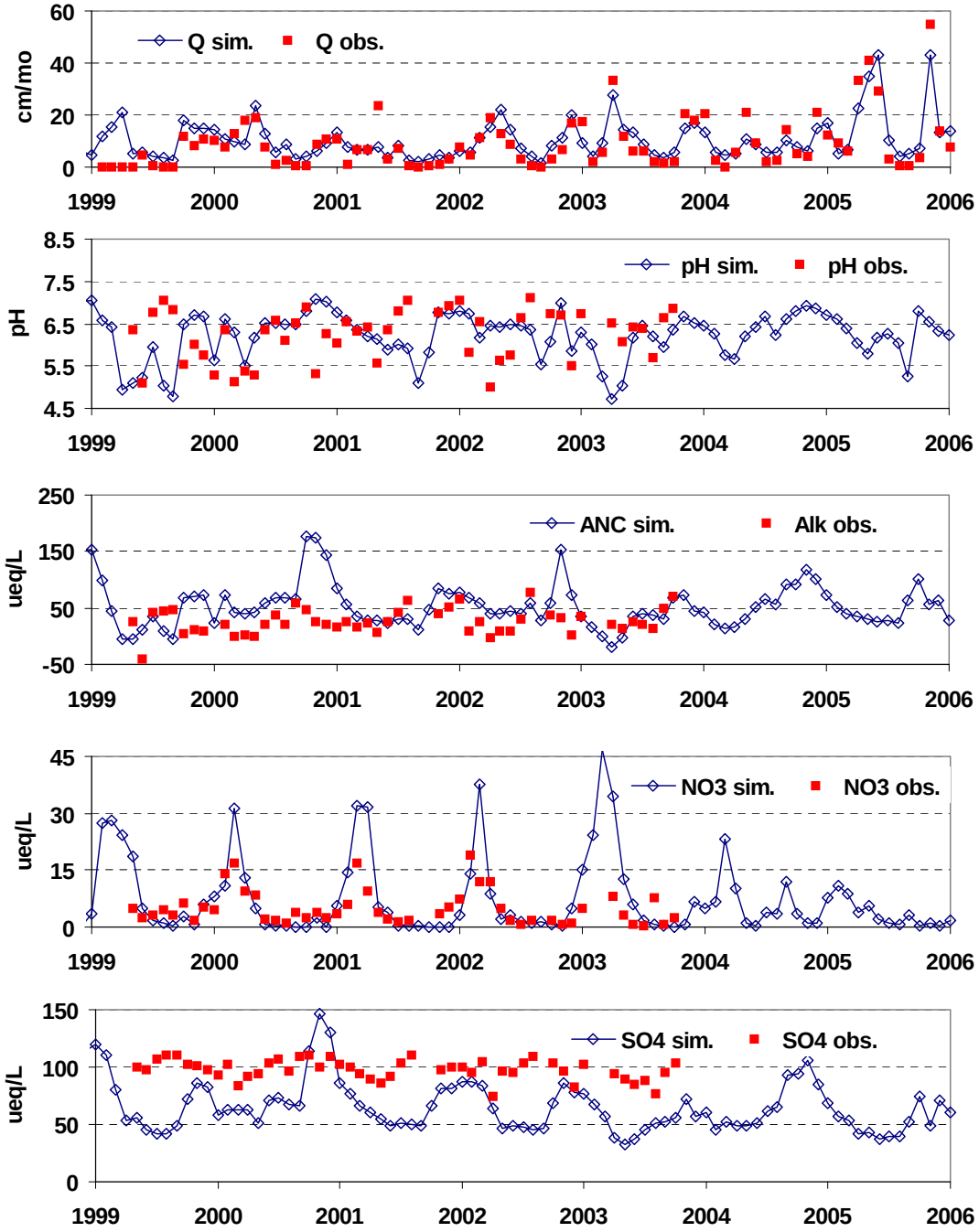


Observed vs. simulated soil C for different treatments.

DayCent-Chem Model Processes



Hartman and Baron



Hartman and Baron

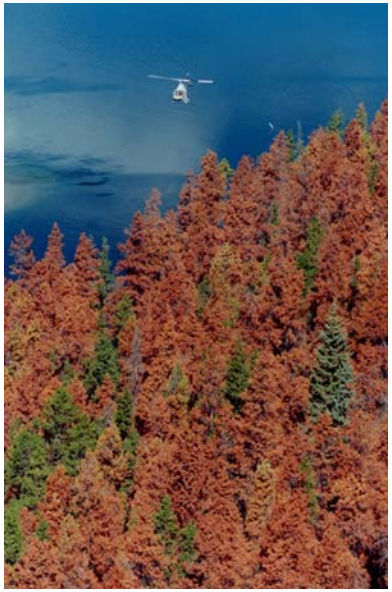
PINE BARK BEETLE OUTBREAK

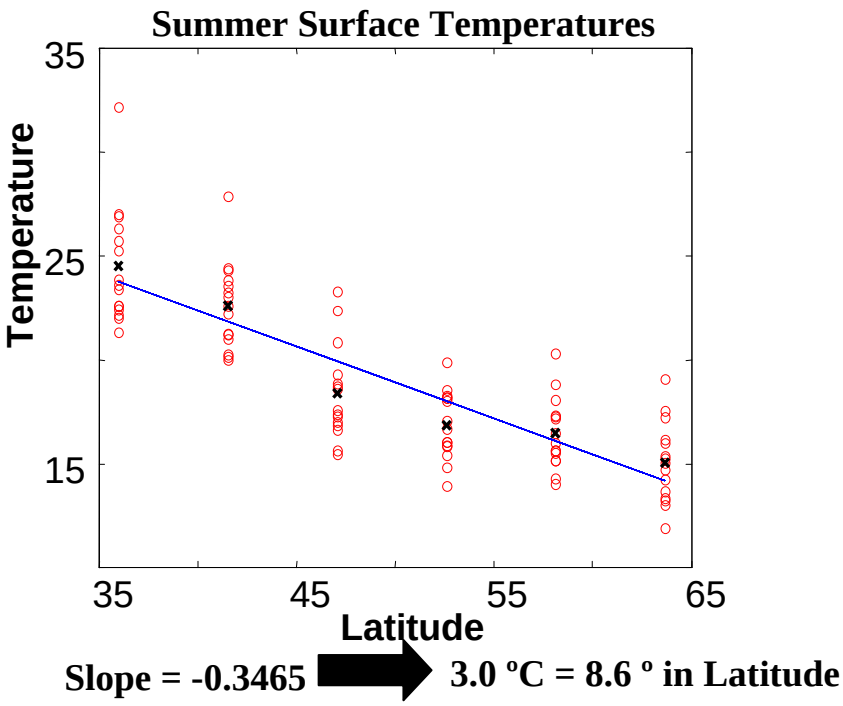
ECOTHRESHOLDS

Understanding thresholds in global change and their implications for decisionmaking

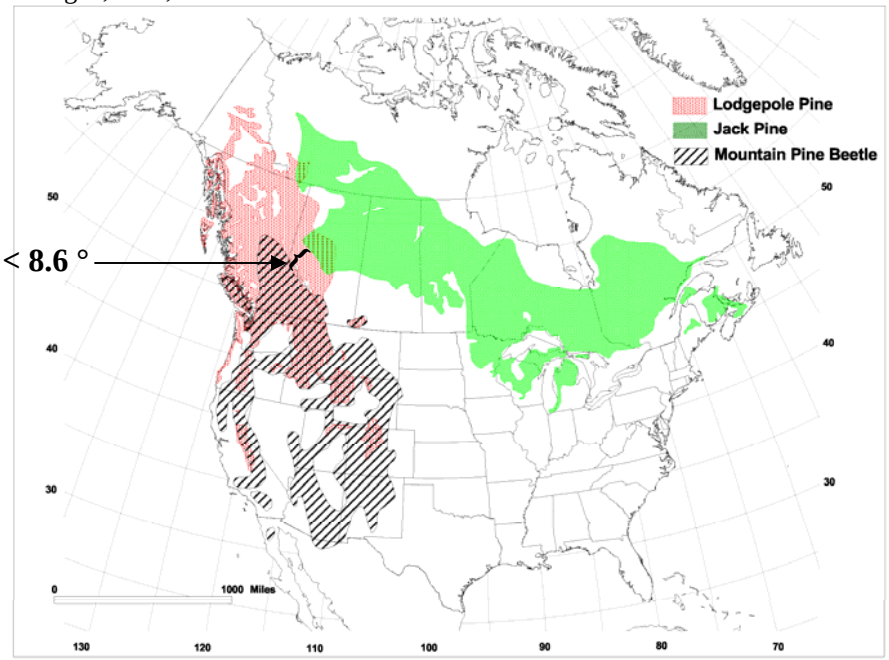
THE H. JOHN HEINZ III CENTER FOR SCIENCE, ECONOMICS AND THE ENVIRONMENT • THE NATURE CONSERVANCY

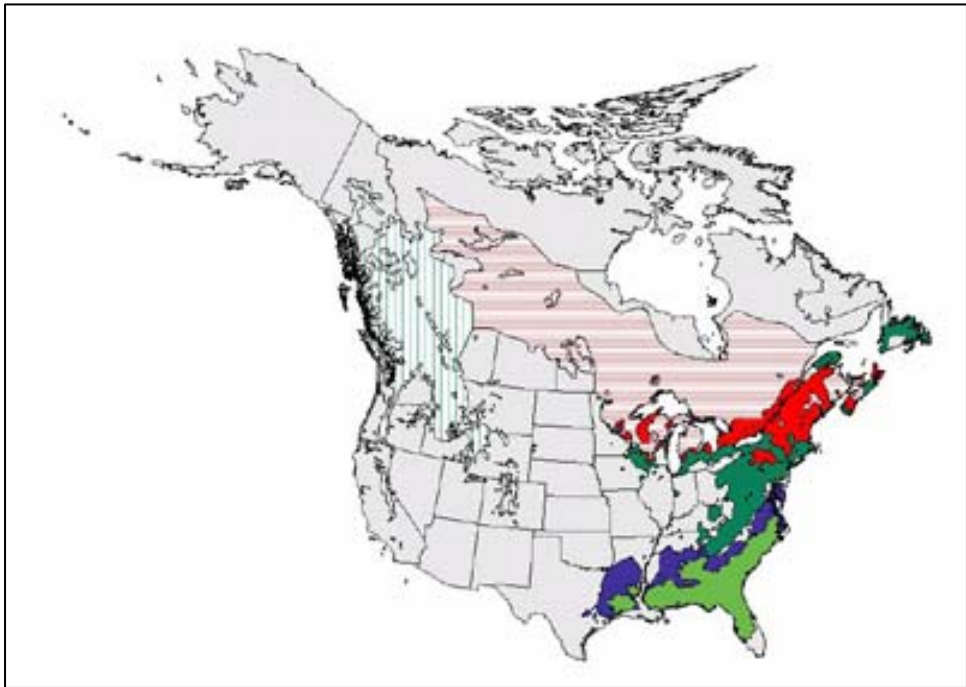
(2) MPB in Canada



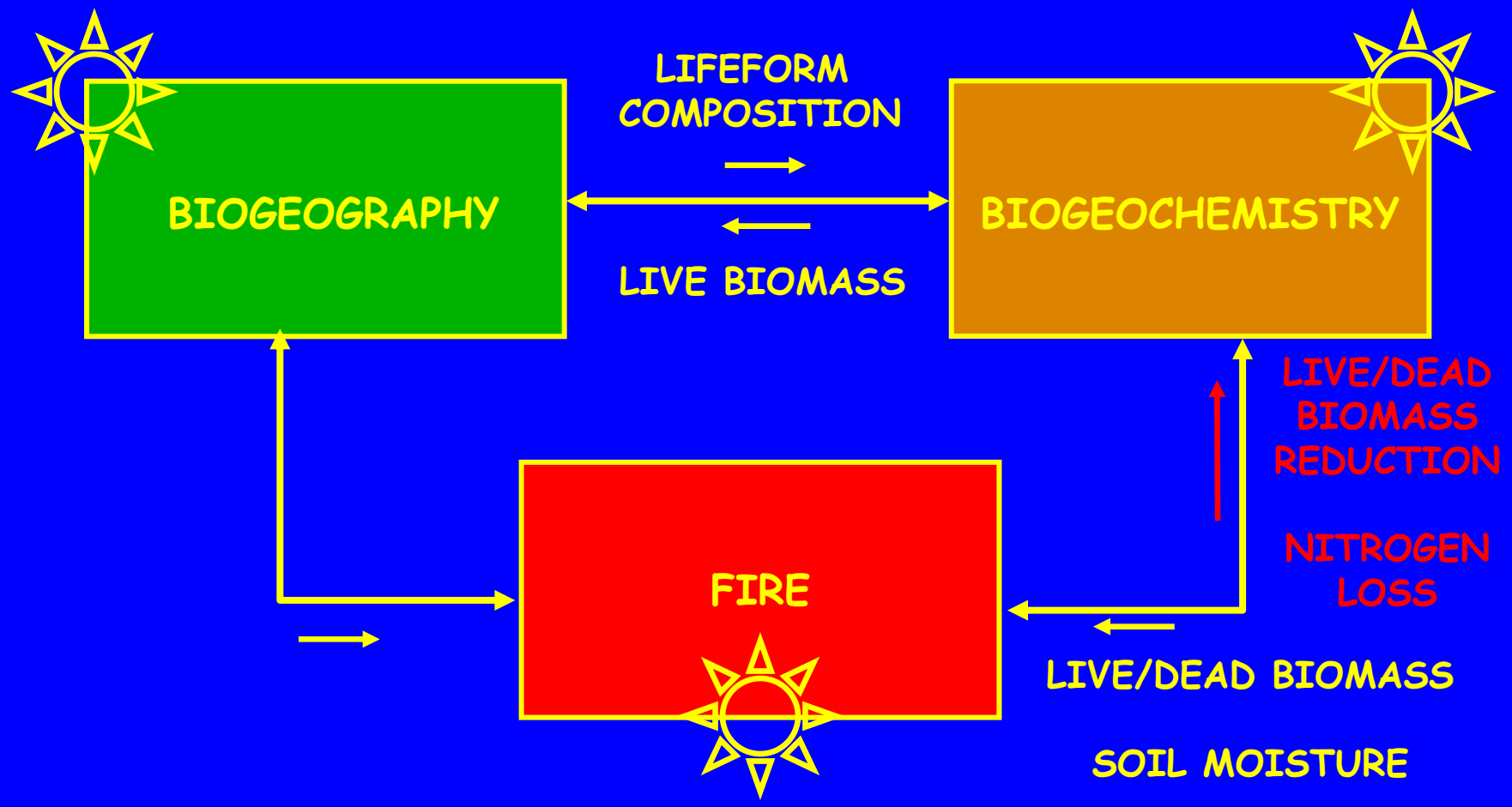


Logan, J. A., and J. A. Powell. 2001. Am. Entomol. 47: 160-173





MC1 DGVM

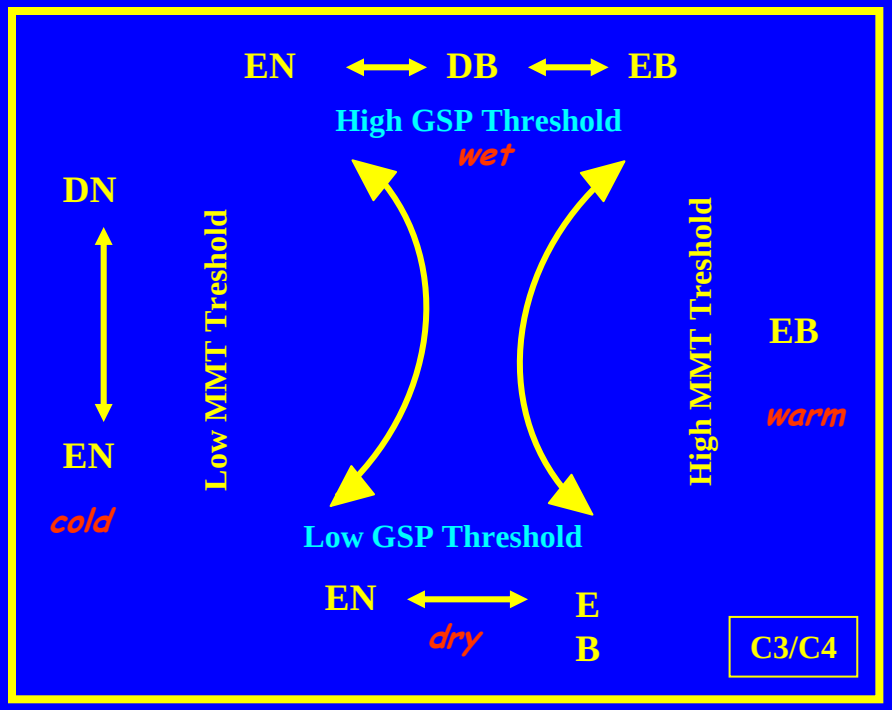


Reads monthly climate (PPT, Tmin, Tmax, Tmp, VPR) and soil texture, depth and bulk density

Bachelet

BIOGEOGRAPHY RULES

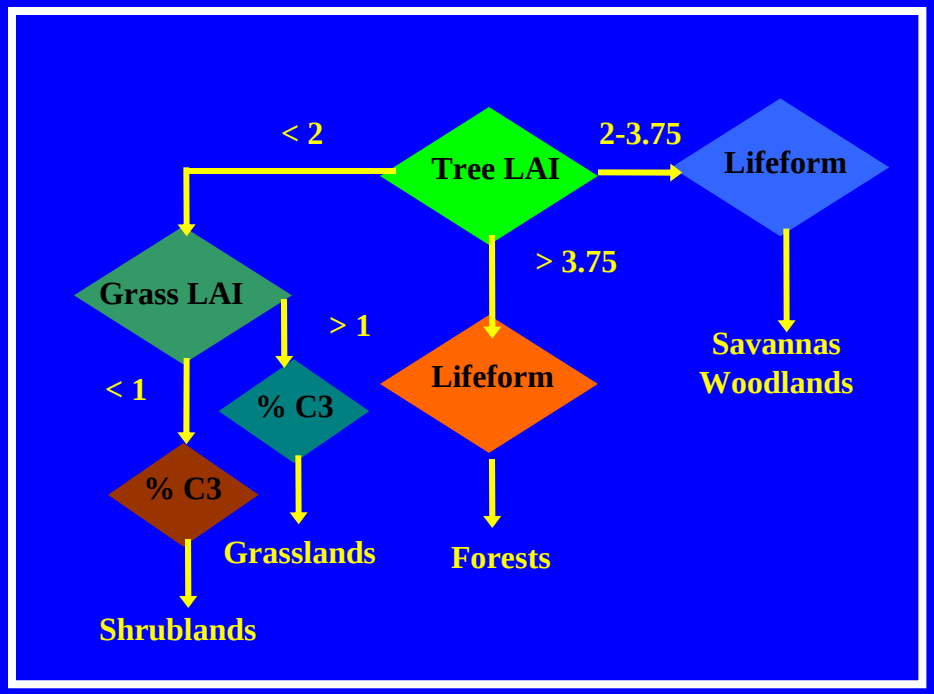
LIFEFORM INTERPRETER



Includes trees (shrubs are small trees)
.deciduous vs evergreen,
.needleleaf vs broadleaf

. Includes C3 and C4 grasses

VEGETATION CLASSIFIER

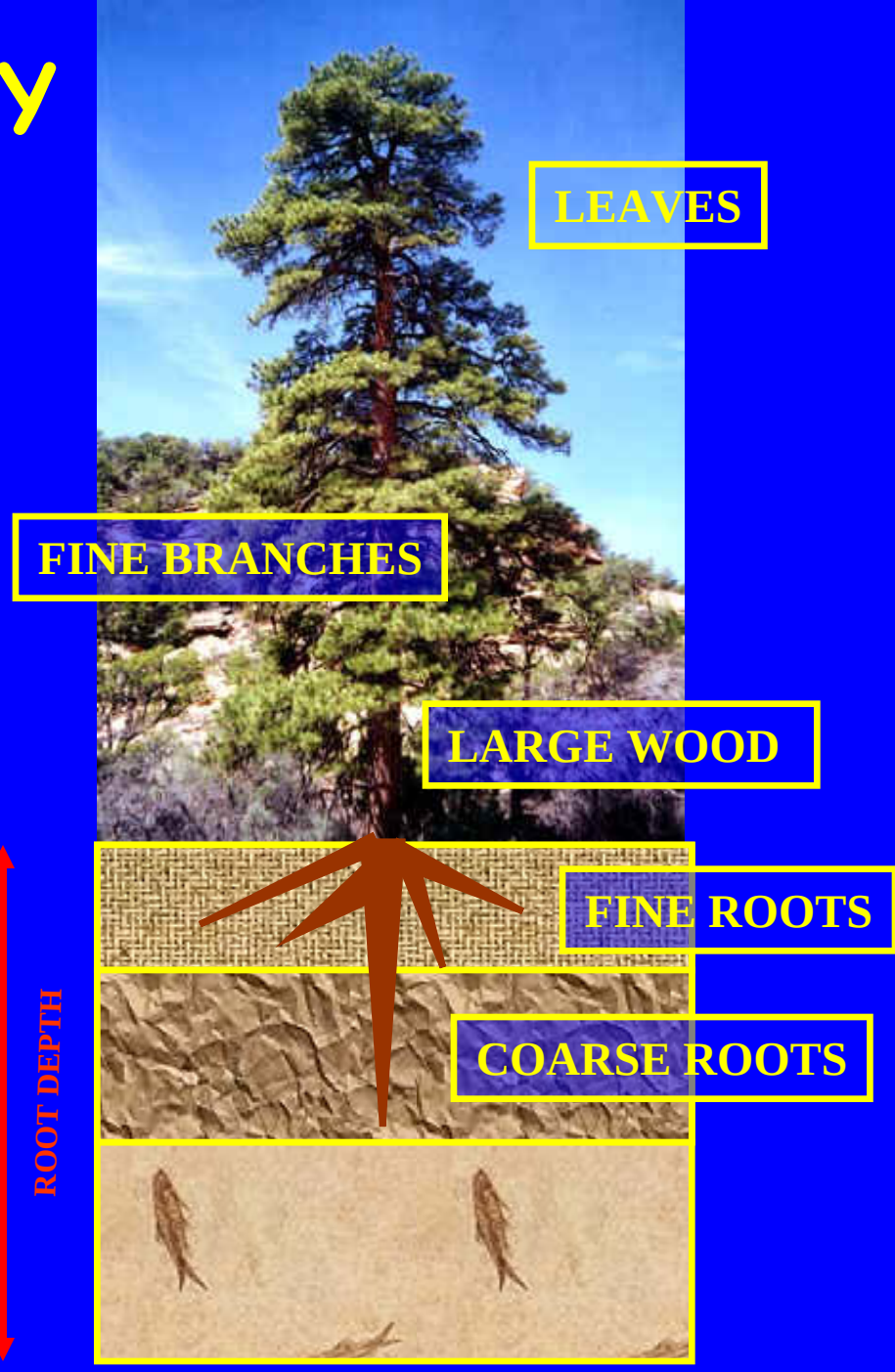


GSP: growing season ppt
MMT: mean monthly temp
E: evergreen, D: deciduous
N: needleleaf, B: broadleaf

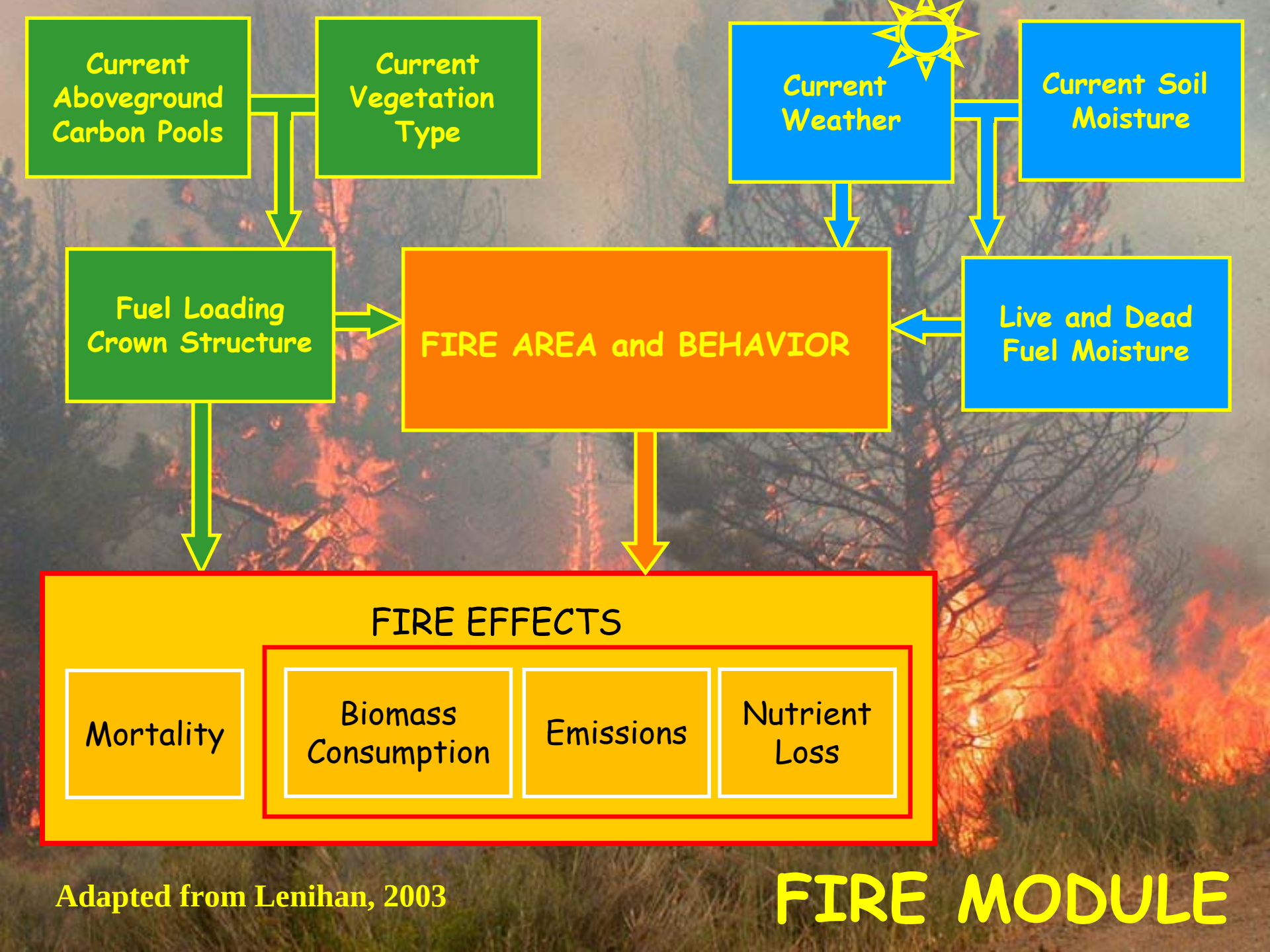
Bachelet

BIOGEOCHEMISTRY MODULE

- Modified version of CENTURY (Ojima, Parton et al. CSU)
- Simulates NPP, decomposition, N & water cycling
- Simulates competition between trees and grasses for light, water, and N



Bachelet



Adapted from Lenihan, 2003

FIRE MODULE

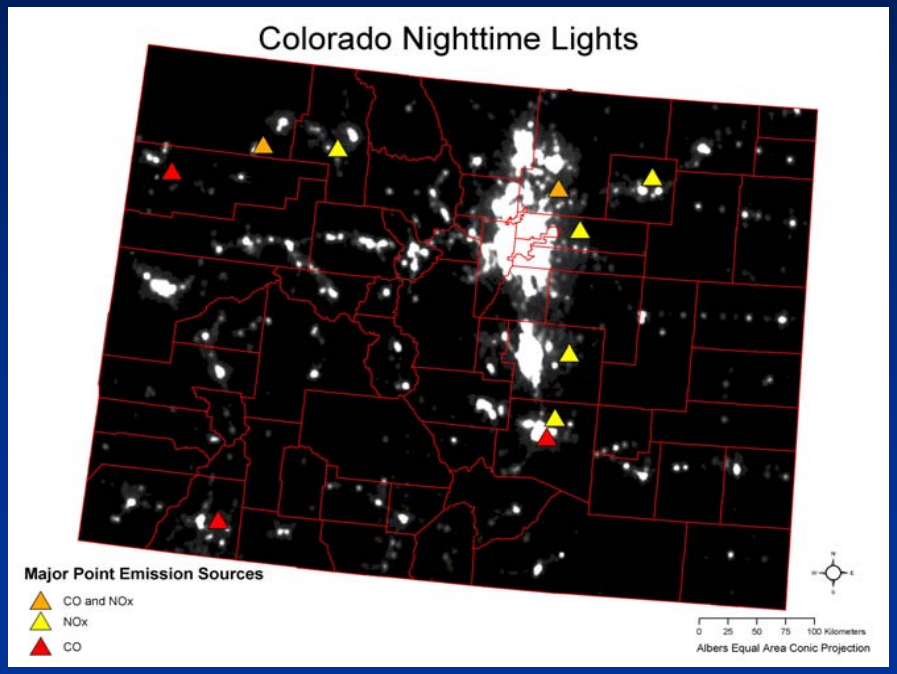
INTEGRATED MOUNTAIN STUDIES

- REGIONAL TELECONNECTIONS
- SENSITIVITY TO CLIMATE CHANGE
- INSECT PEST AND FIRE

Baron

Colorado Regional Sub-Systems

Mountains/Forests



Agricultural

Freshwaters

Urban/Developed

Grasslands/Range

Baron

Intensive Process Studies → Extensive and Network Based Regional Studies

Loch Vale Watershed Long-Term Monitoring

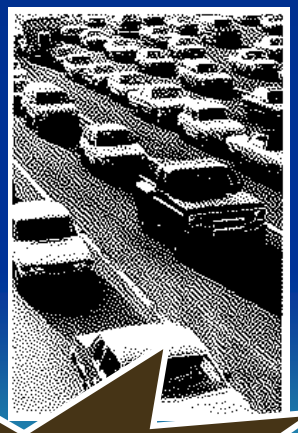
- Cycles, Fluxes, and Ecological Responses to C & N
- Hydrology Snow Processes Energy Balance
- Responses to Climate Variability
- Paleoprocesses
- Seasonal Redox of Trace Elements
- Human Induced Change to Rocky Mountains
- South Platte Basin Feedbacks to Climate
- LTER Intersite Comparisons
- Forest Service Wilderness Lakes Monitoring

Drought

FIRE

Decisions About ?

Growth



Transportation

Baron

How do we assess VULNERABILITY?

The South Platte environment will respond to pressures from human activities and climate variation.
Those responses can cross
CRITICAL THRESHOLDS
that affect ecosystem function, ability to provide things we need (goods and services), or the quality of life.

- SCENARIO DEVELOPMENT
- SENSITIVITY ANALYSES
- CRITICAL RESPONSE ANALYSIS
- ADAPTIVE CAPACITY ASSESSMENT
- METRIC DEVELOPMENT

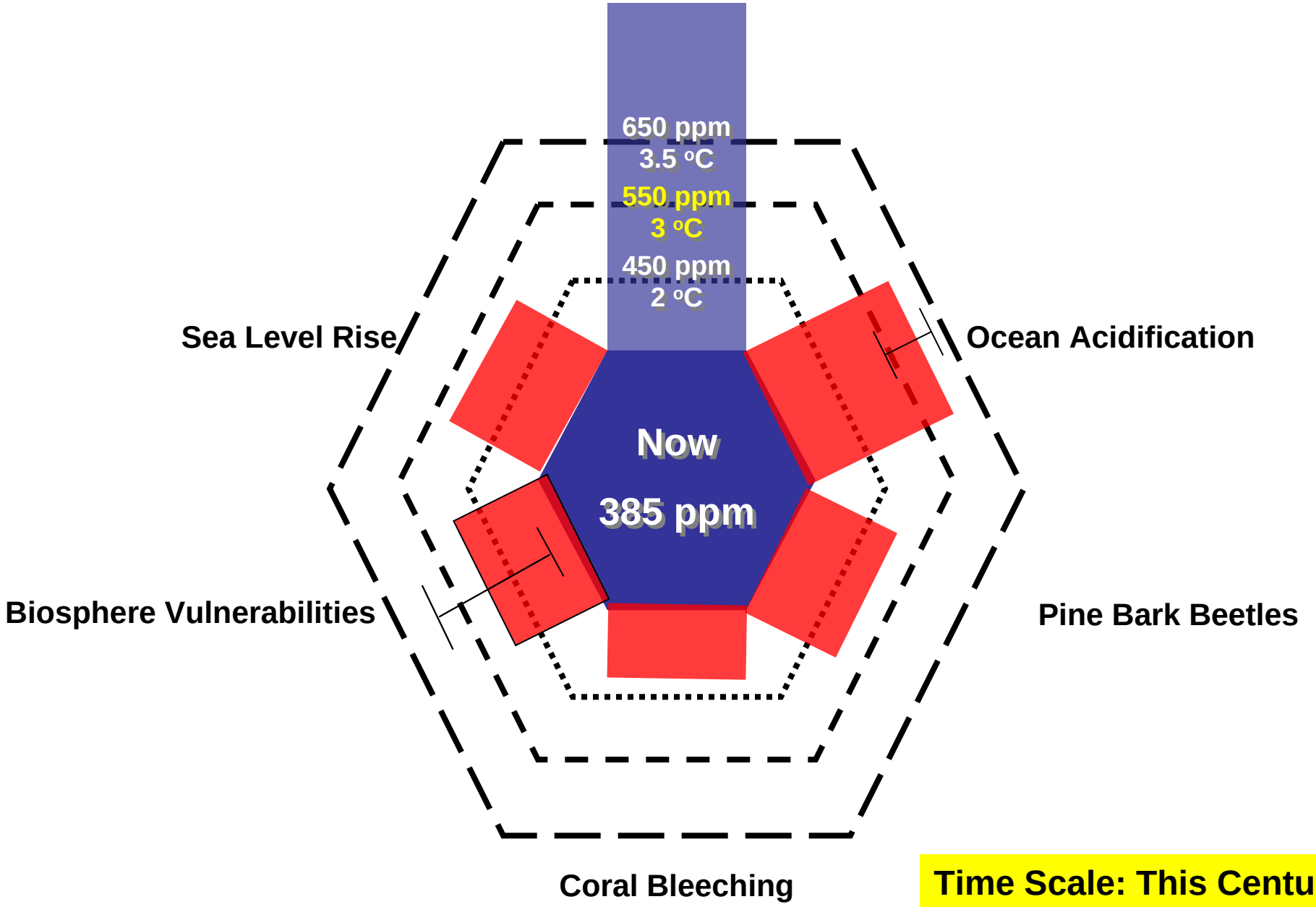
Baron

ISSUES

- Multiple Stresses
- Multiple Scales of Space-Time-Biota (Global to Genes)
- Well Tested Modeling Frameworks
- Complex Adaptive Systems of the Coupled Human-Environmental System

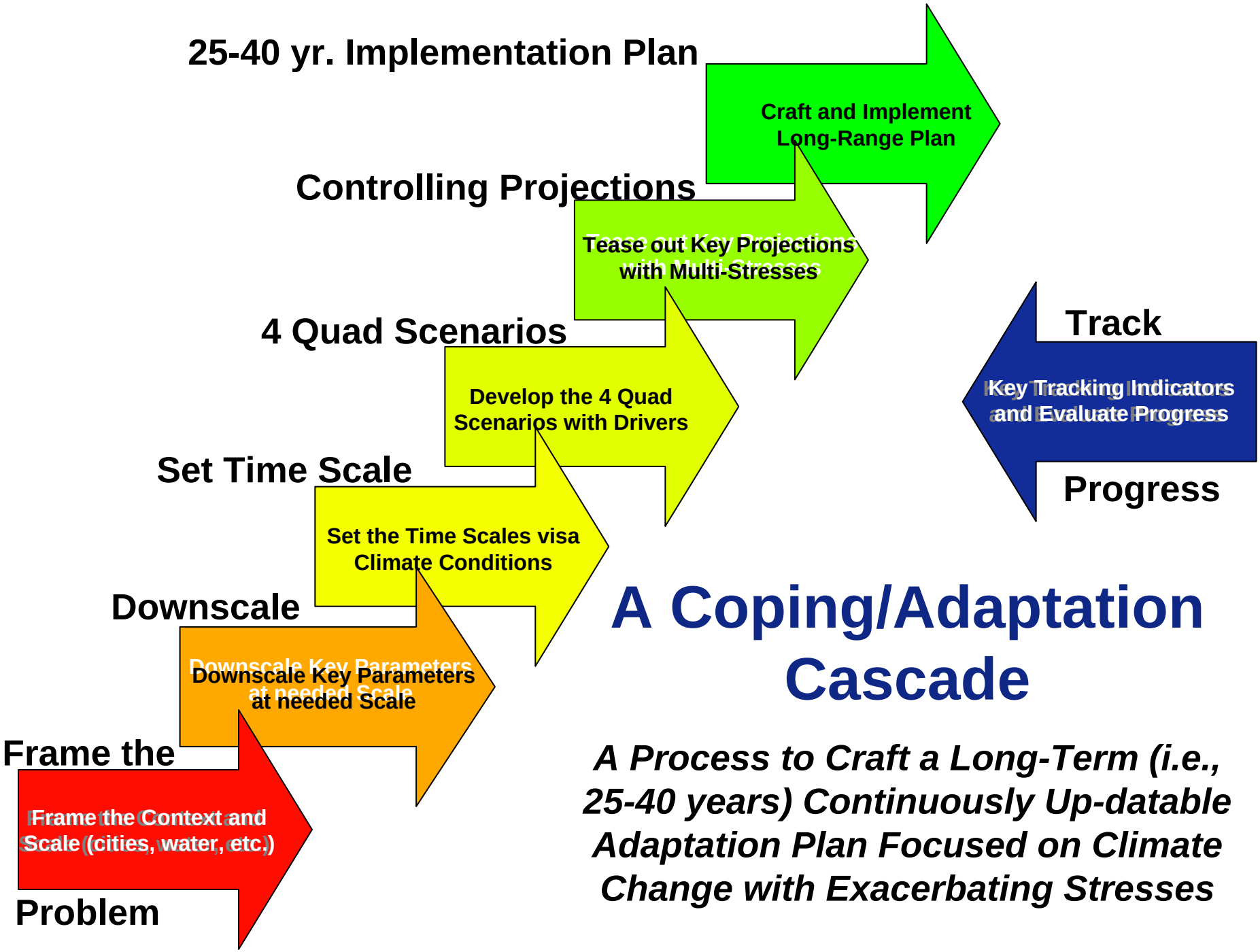
A Concept for a Adaptation/Impacts Multi-Space

A framing within which coping strategies are addressed



ADAPTATION DESIGN

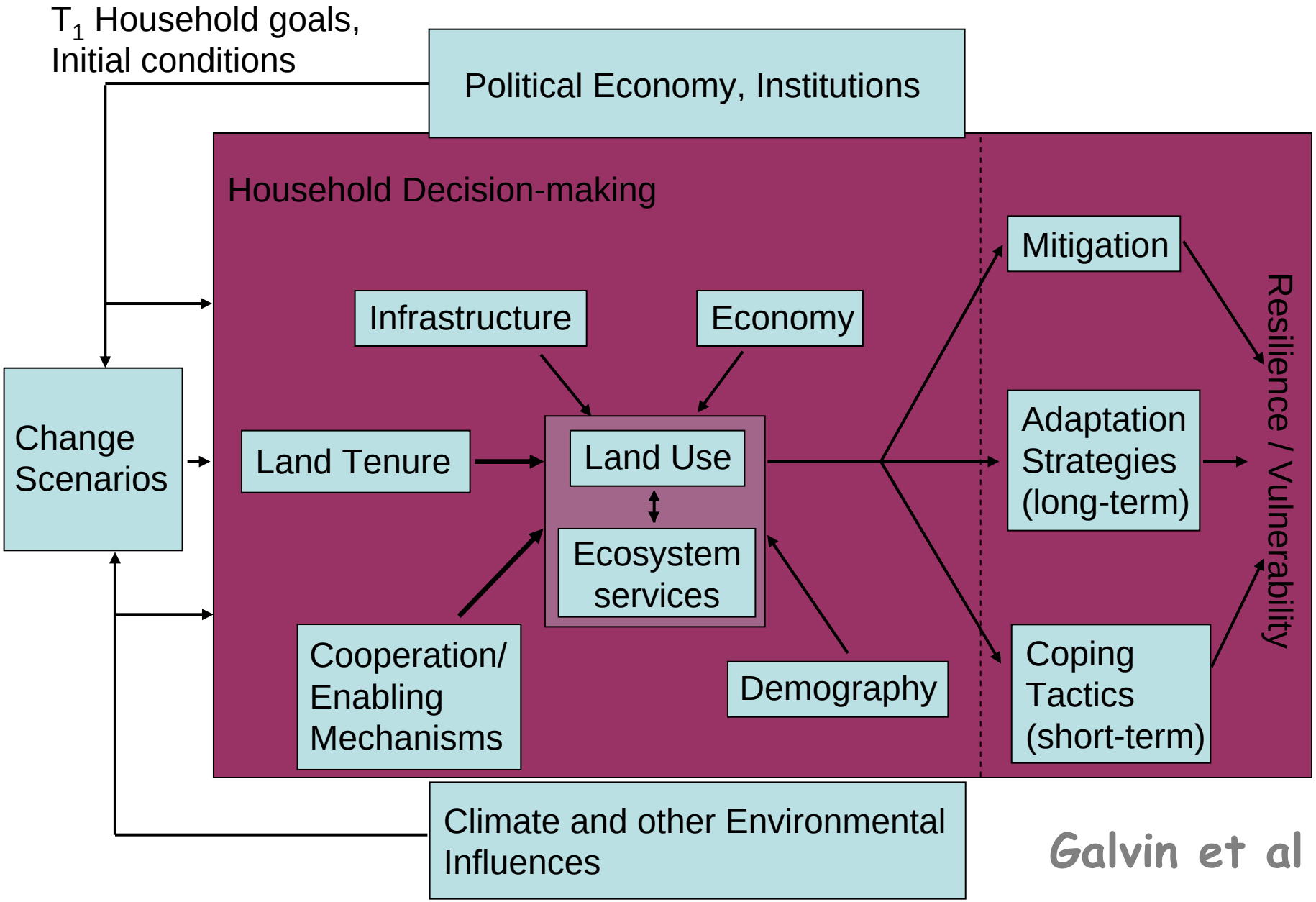
- Adaptive Management practices are local and need to take into account the complex, non-linear behaviour of socio-ecological systems
- Use of appropriate scenarios and downscaling techniques of climate change effects
- Full risk/uncertainty assessments
- Projects need to be linked to capacity building & technology transfer
- Co-development of an integrative management plan should treat the system as a socio-ecological system



A Coping/Adaptation Cascade

A Process to Craft a Long-Term (i.e., 25-40 years) Continuously Up-datable Adaptation Plan Focused on Climate Change with Exacerbating Stresses

DECISION MAKING FRAMEWORK



Galvin et al

SUMMARY

- Application of Adaptation Cascade in partnership with local communities, states, and other resource management entities
- Development of Adaptive management strategies to deal non-linearities of global change and multi-scaled stresses
- Developing technological, scientific, socio-economic tools for addressing adaptation needs

THANK YOU