ESS Week 8, Modeling

Tuesday February 22, 2011

1. Announcements
2. Overview of Workshop and Recap of Stocks/Flows
3. Dominique Bachelet: Dynamic Vegetation Model MC1, Hydrology is key to simulating the future
4. Students create Conceptual Hydrology Stock-Flow Model
5. Students, then Judy, present their Models
6. Break for dinner (30 min)
7. Dominique comments, then runs the model
8. We look at the code
9. Seminar (about 9pm)

Recap : Stocks/Flows

1. Identify the major stocks in your model.
2. Identify major flows between stocks.
3. Construct the basic structure of your model.
4. Describe the flows between stocks. Constant? Dependent on the source stock? Dependent on the receiving stock? Dependent on another flow elsewhere in the model?
5. Examine steady-state conditions. Write out the equation for each stock. If your system is “closed”, calculate the total amount of material in the system. Solve for steady-state conditions.
6. Examine transient dynamics. Collect available data stocks, flows, or parameters. Draw a STELLA Model. Run the simulation.

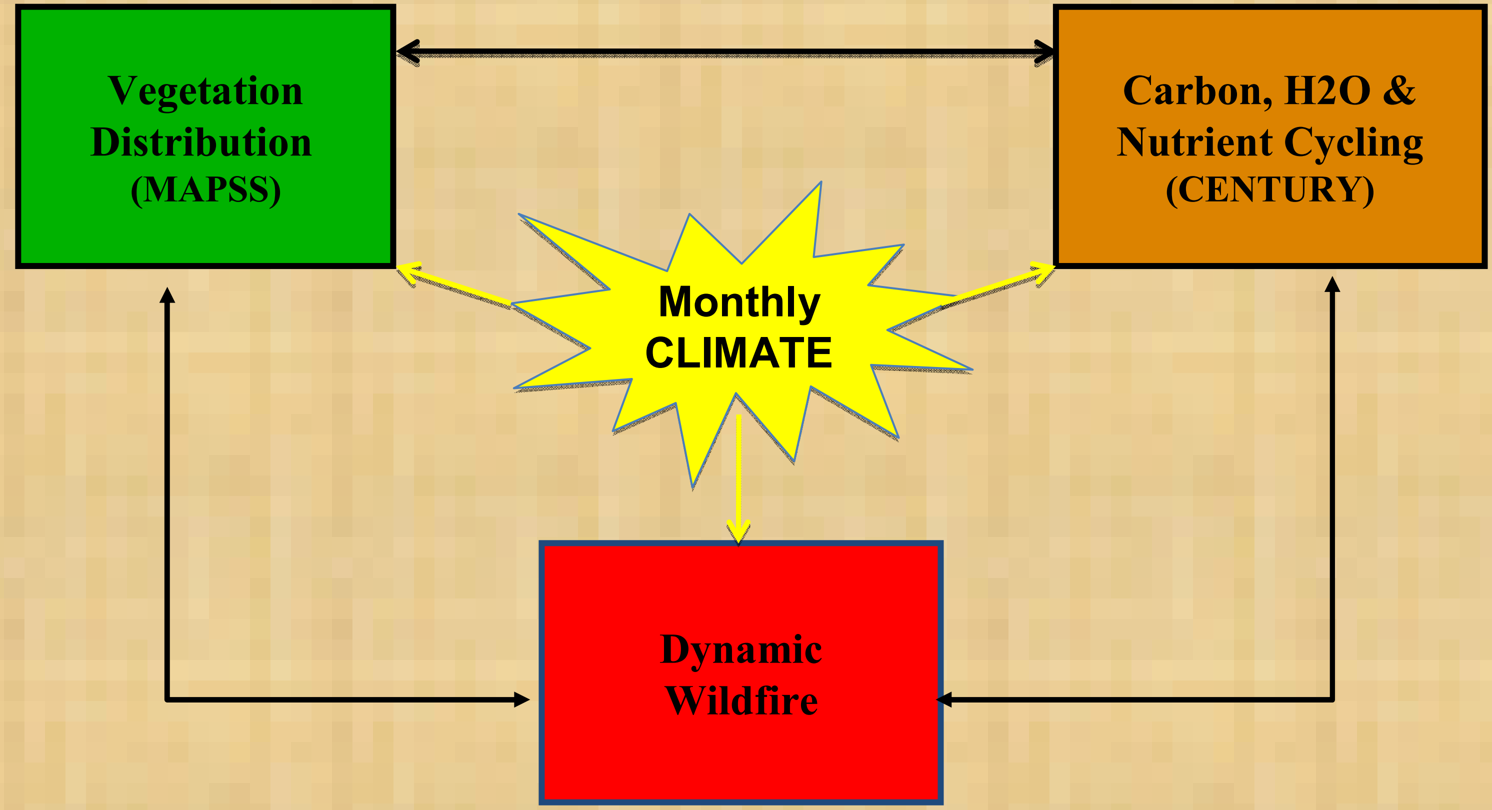
You might need calculus, linear algebra, or differential equations to solve the model analytically. STELLA makes this type of thinking more accessible.

Dynamic Vegetation Model
MC1

Hydrology is key to simulating the future

Dominique Bachelet, Evergreen February 22, 2011

MC1 Dynamic Global Vegetation Model



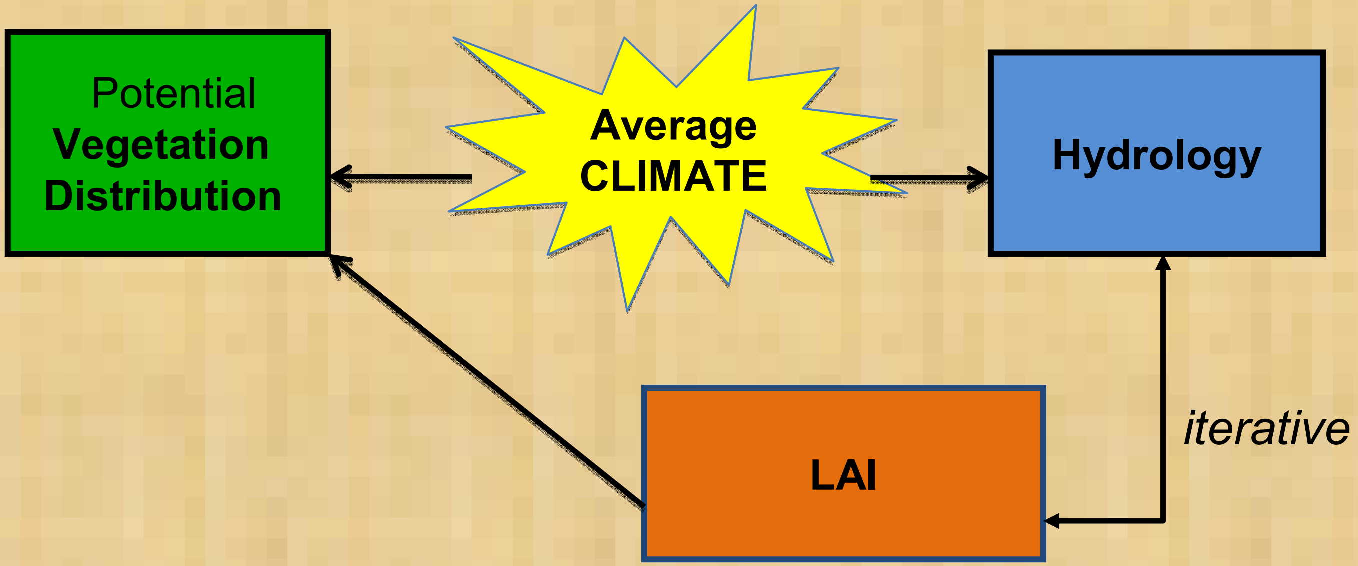
Vegetation Distribution (MAPSS)

Carbon, H2O & Nutrient Cycling (CENTURY)

Monthly CLIMATE

Dynamic Wildfire

MAPSS Biogeography Model
Equilibrium model


Potential
Vegetation Distribution

Average CLIMATE

Hydrology

LAI

iterative

Main assumption:
potential vegetation will use all the available soil water to maximize its leaf area

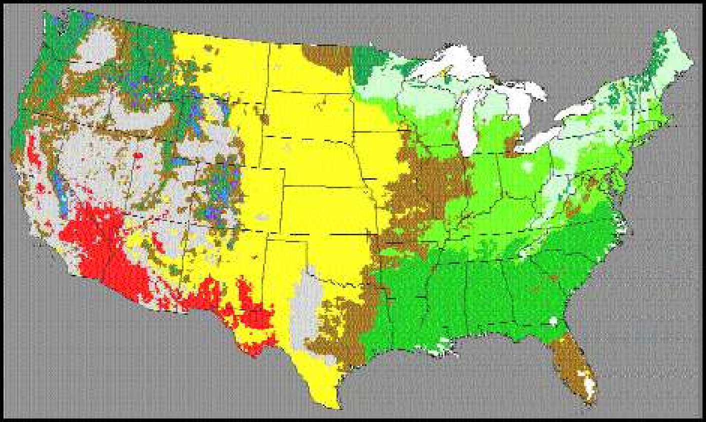
CLIMATE CHANGE IMPACTS ON THE UNITED STATES

Ecosystem Models

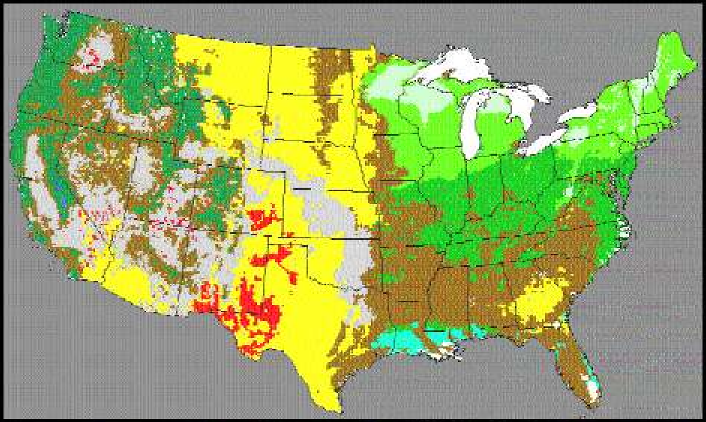
Maps of current and projected potential vegetation distribution for the conterminous US. Potential vegetation means the vegetation that would be there in the absence of human activity. Changes in vegetation distribution by the end of the 21st century are in response to two climate scenarios, the Canadian and the Hadley. Output is from MAPSS (Mapped Atmosphere-Plant-Soil System).

- 🟦 Tundra
- 🟪 Taiga / Tundra
- 🟩 Conifer Forest
- ⬜ Northeast Mixed Forest
- 🟩 Temperate Deciduous Forest
- 🟩 Southeast Mixed Forest
- 🟦 Tropical Broadleaf Forest
- 🟫 Savanna / Woodland
- ⬜ Shrub / Woodland
- 🟨 Grassland
- 🟥 Arid Lands

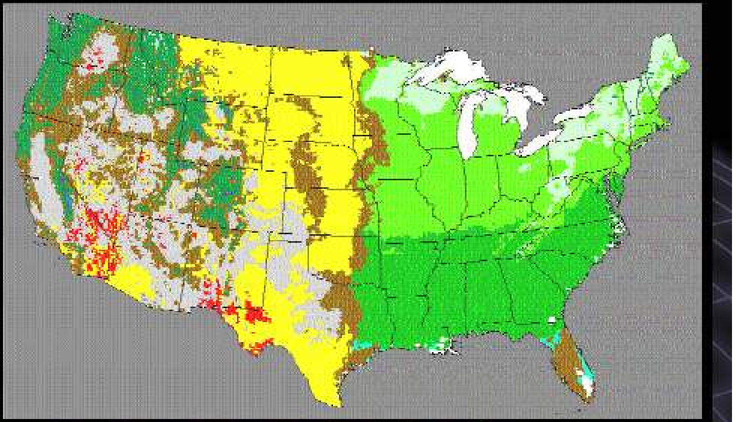
Current Ecosystems



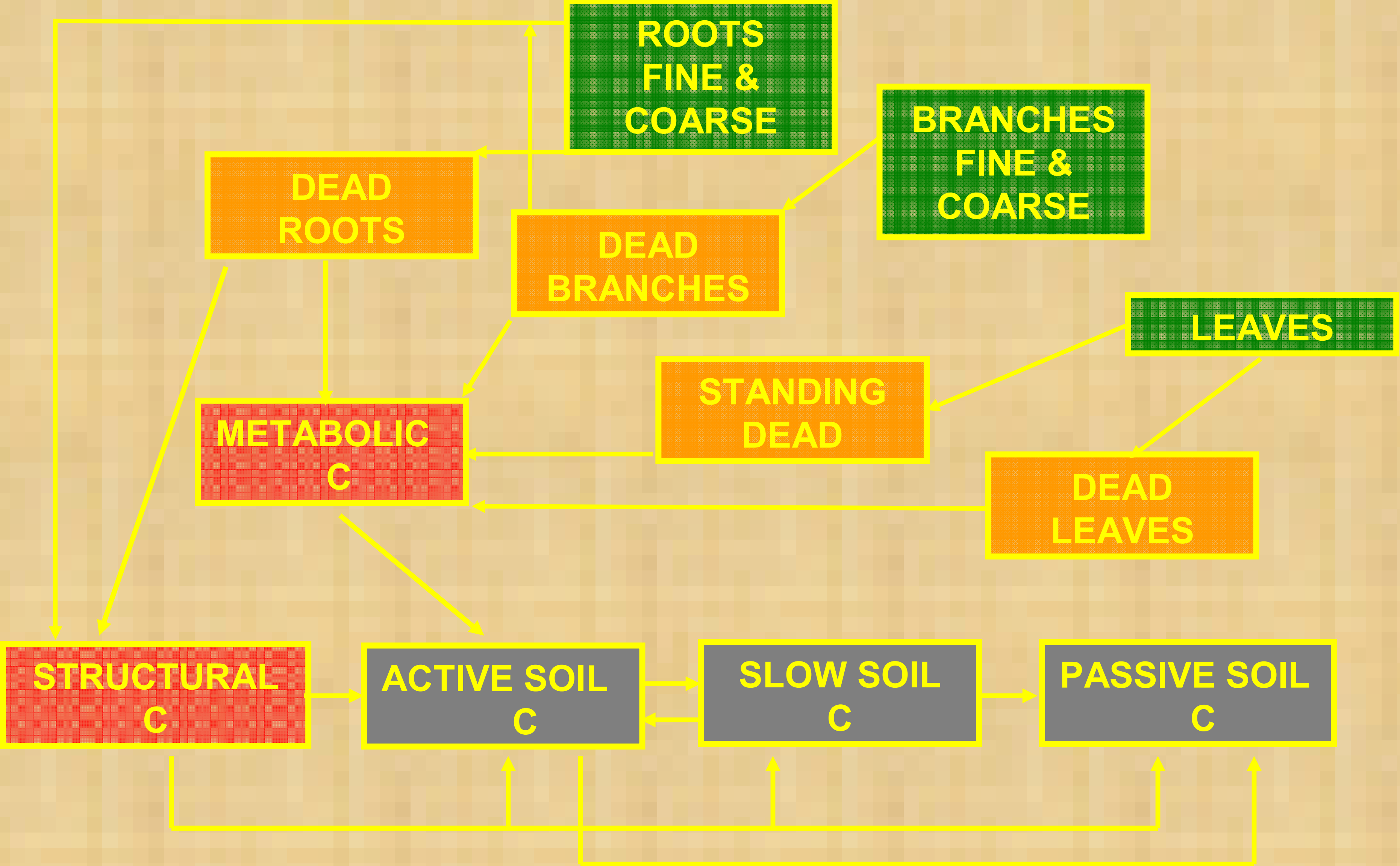
Canadian Model



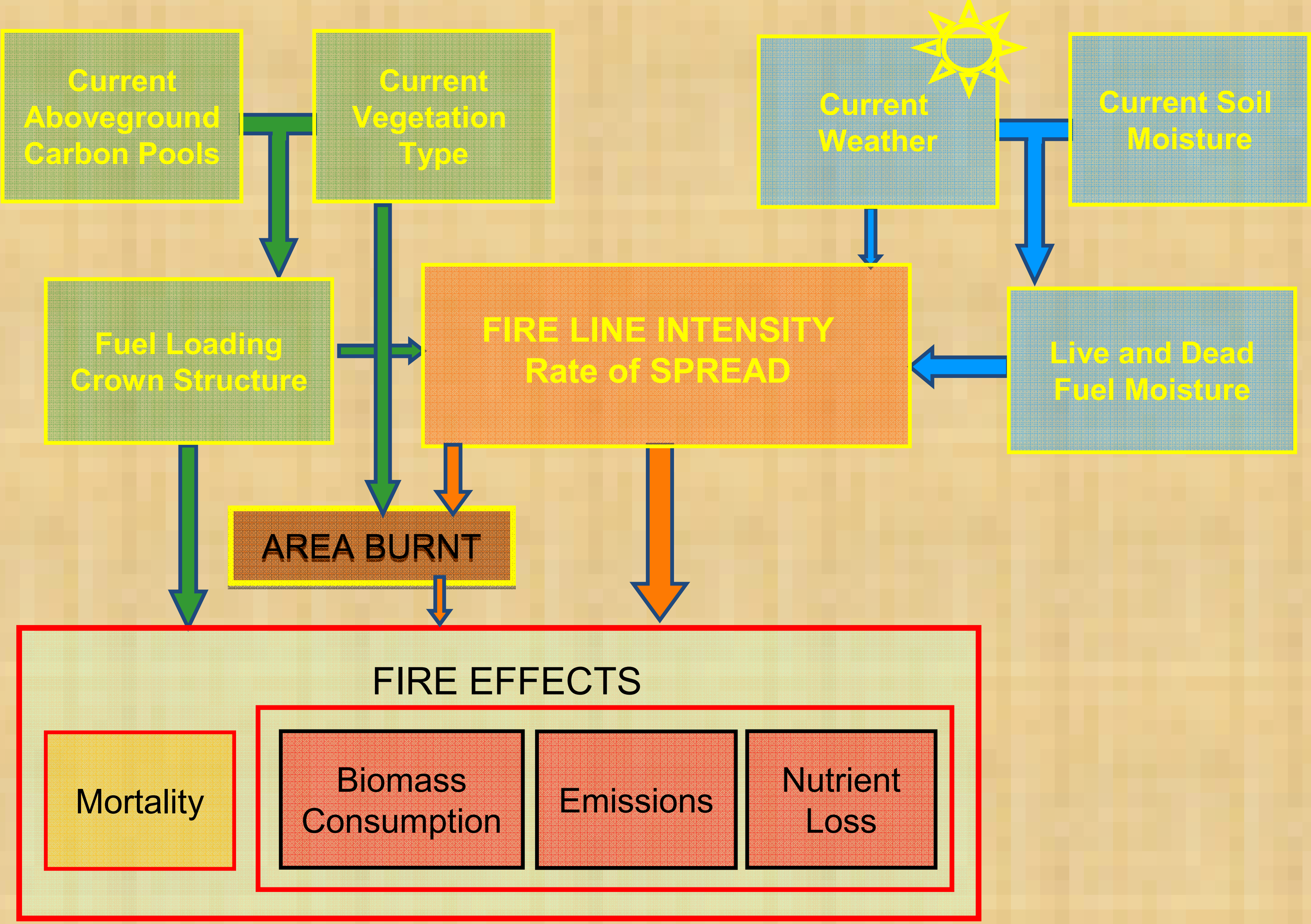
Hadley Model



CENTURY biogeochemistry model



Fire model



Current Aboveground Carbon Pools

Current Vegetation Type

Current Weather

Current Soil Moisture

Fuel Loading Crown Structure

FIRE LINE INTENSITY
Rate of SPREAD

Live and Dead Fuel Moisture

AREA BURNT

FIRE EFFECTS

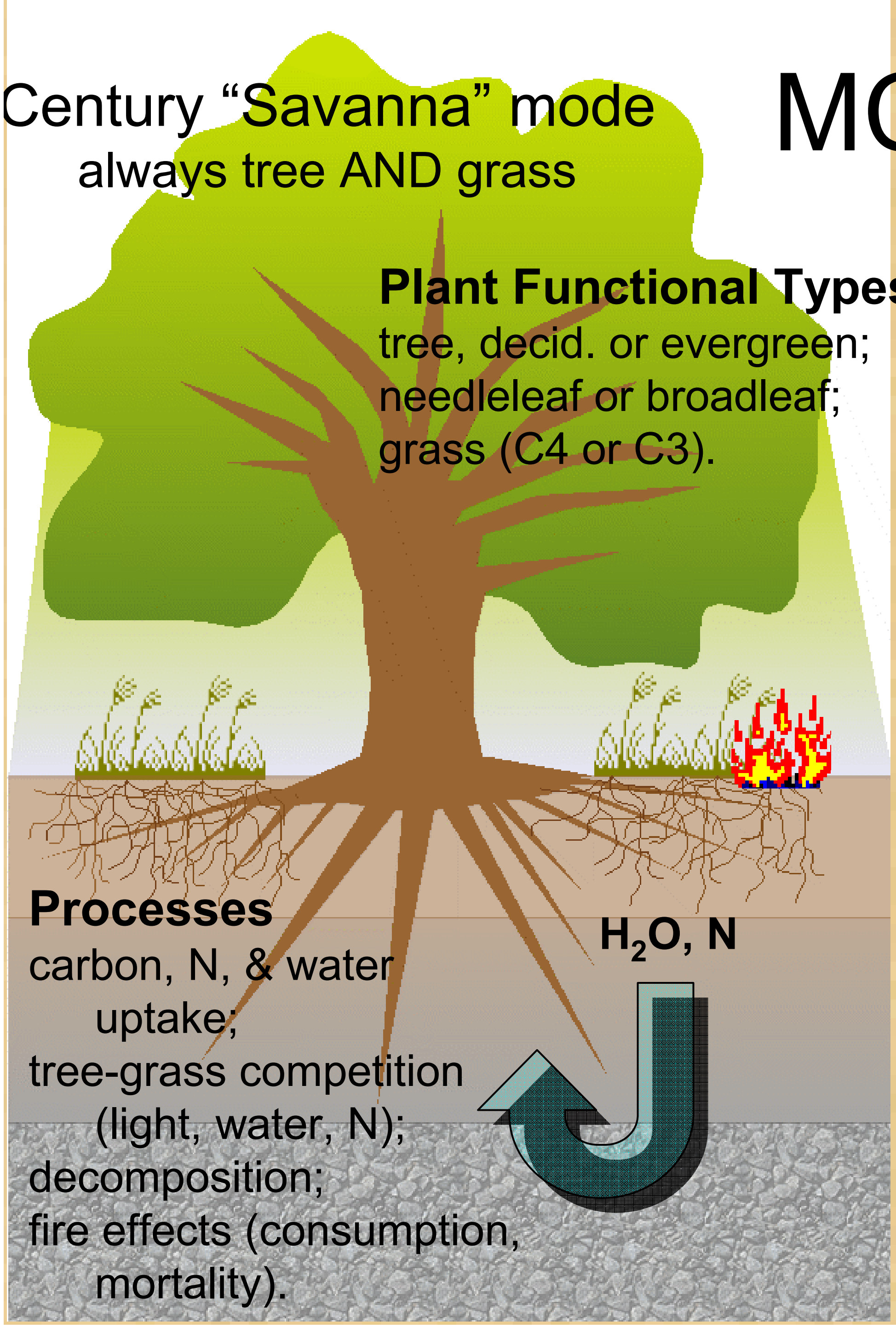
Mortality

Biomass Consumption

Emissions

Nutrient Loss

MC1



Century “Savanna” mode
always tree AND grass

Plant Functional Types
tree, decid. or evergreen;
needleleaf or broadleaf;
grass (C4 or C3).

Processes
carbon, N, & water uptake;
tree-grass competition (light, water, N);
decomposition;
fire effects (consumption, mortality).

SOME MODEL ASSUMPTIONS

Trees shade grasses (light competition)

Saturated water flow (bucket)

Different rooting depths between trees and grasses determine competition for water and nutrients

Plant parts have fixed min and max C/N, specific per lifeform (N limitation)

Fire consumes aboveground biomass (no roots), 20% of the N is returned to the

MC1 Inputs (gridded)

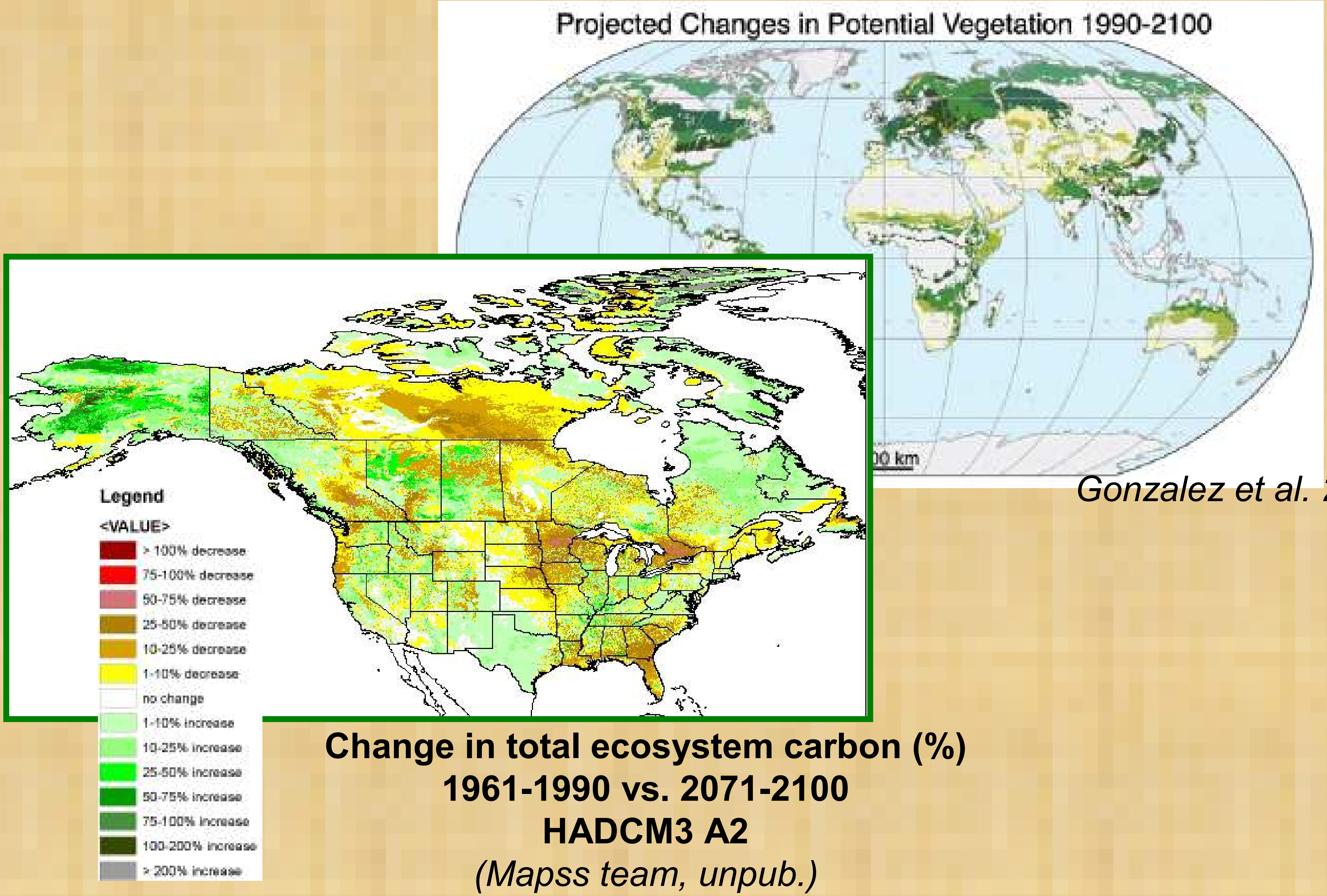
- Soil information
  - mineral soil depth
  - % sand and % clay in 3 layers
  - % rock fragment in same layers
  - bulk density
- Monthly climate inputs (time series) include:
  - Tmin and Tmax
  - Precipitation
  - Vapor pressure deficit (dew point Temp, VPR…)
  - 1895-2009 and projections to 2100

MC1 protocol

- Run MAPSS equilibrium model (fixed fire) on historical average climate to initialize vegetation distribution, run biogeochemistry module to initialize carbon stocks (stable soil carbon, several 1000 years)
- Run iteratively over several 100s years biogeography and dynamic fire module to stabilize fire-effected carbon stocks (NBP ~0)
- Run with historical and future climate

lobal projections of vegetation shifts and carbon losses & gains

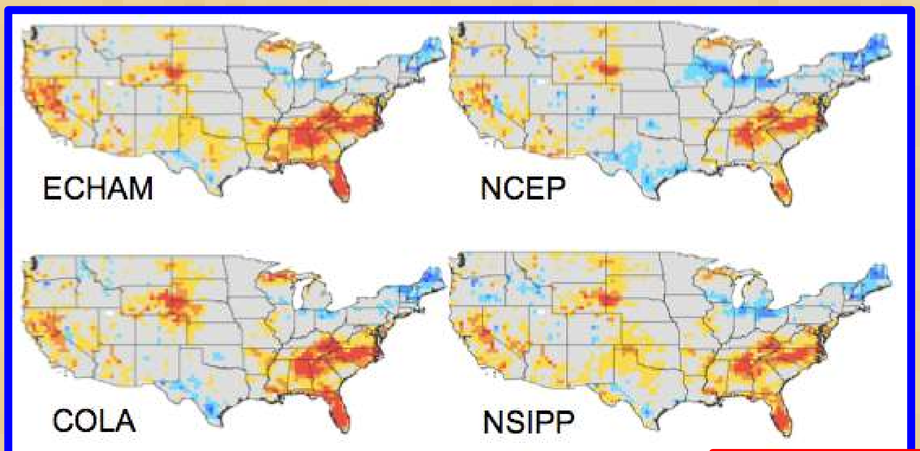
(~50km spatial grain)



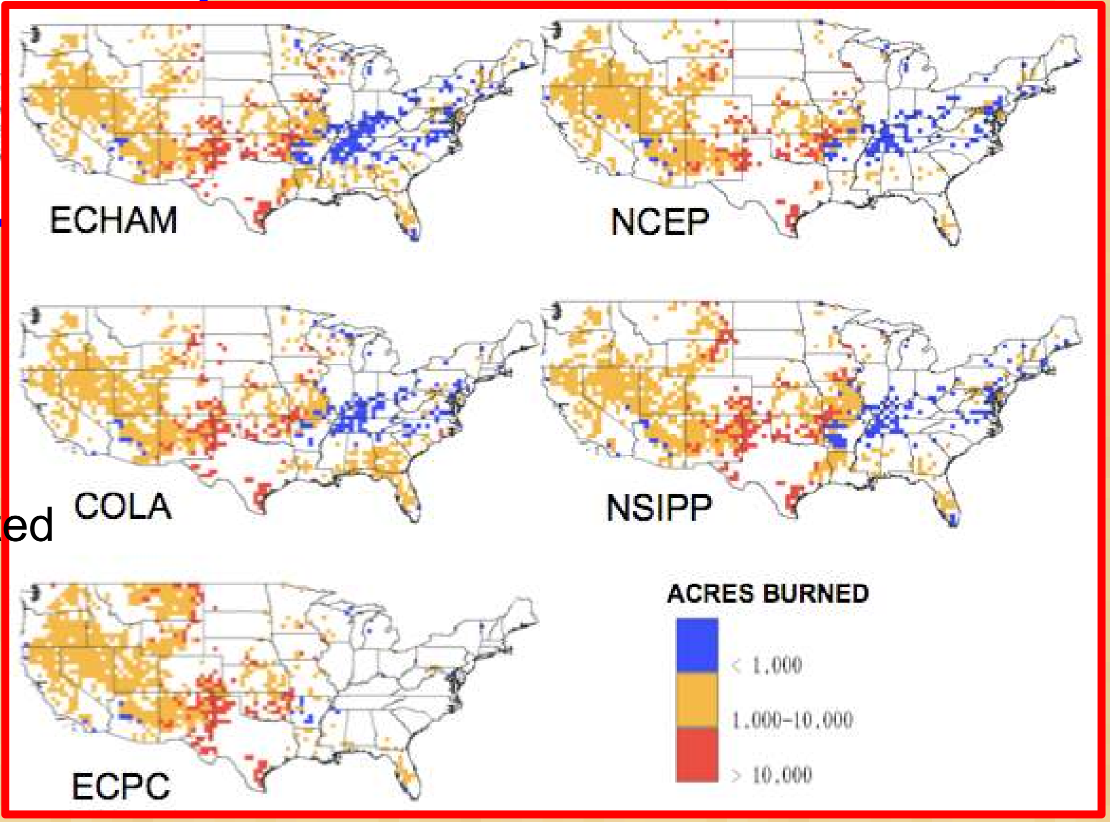
Gonzalez et al. 201

Change in total ecosystem carbon (%)
1961-1990 vs. 2071-2100
HADCM3 A2
(Mapss team, unpub.)

National Projections: Fire Forecast (6 mo)



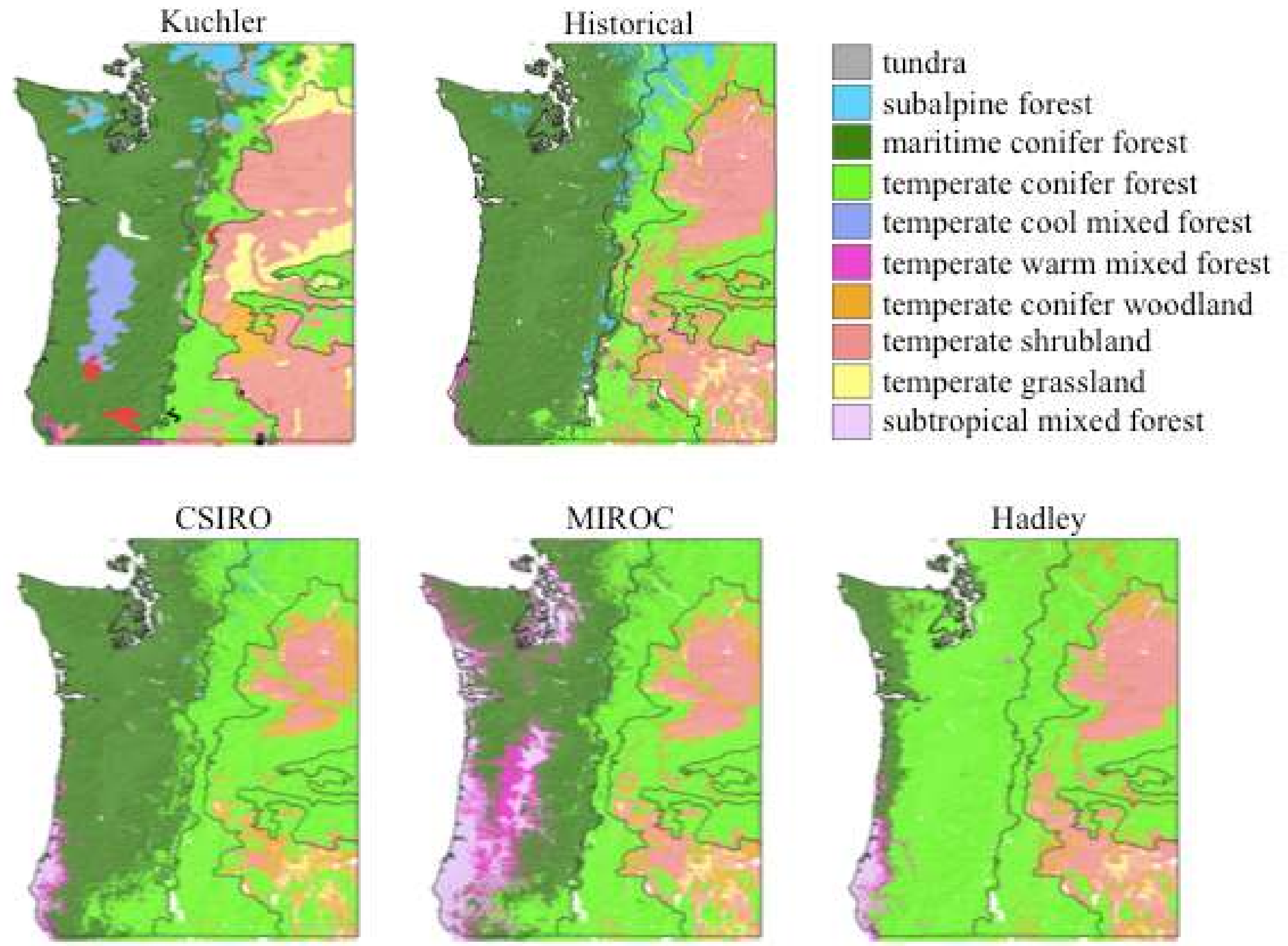
Given a weather forecast …
(2008 PDSI from 5 climate models)



MC1 produces projections of area burned based on projected weather inputs

Lenihan et al., unpub.
spatial grain: ~50km

Regional Simulations (~800m)

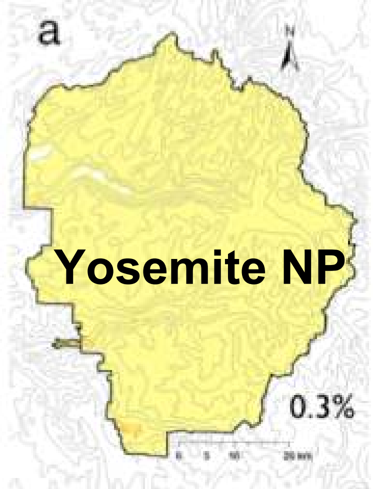


Rogers et al. submitted

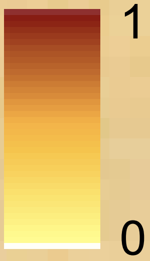
Local Simulations (~800m)

Fraction of net primary production consumed by fire

1967-97



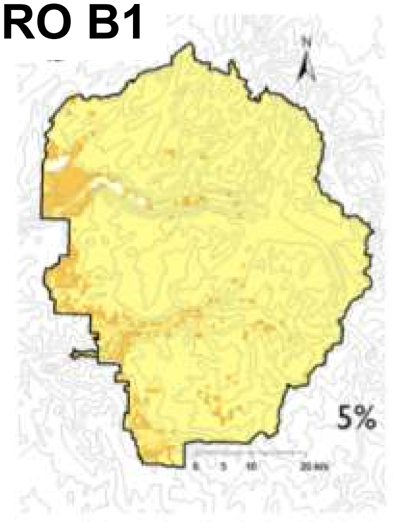
Yosemite NP



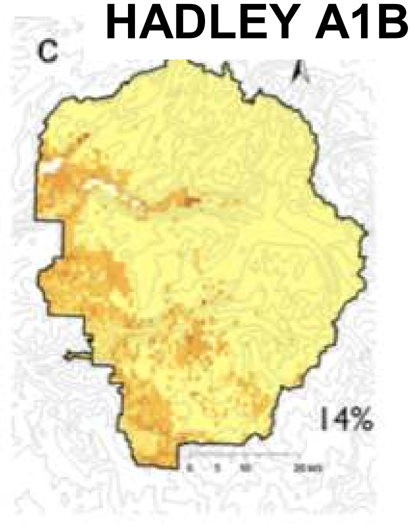
1= carbon fixed is entirely released as fire emissions

2069-2099

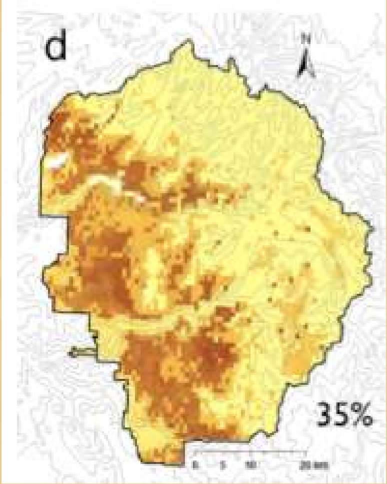
CSIRO B1



HADLEY A1B

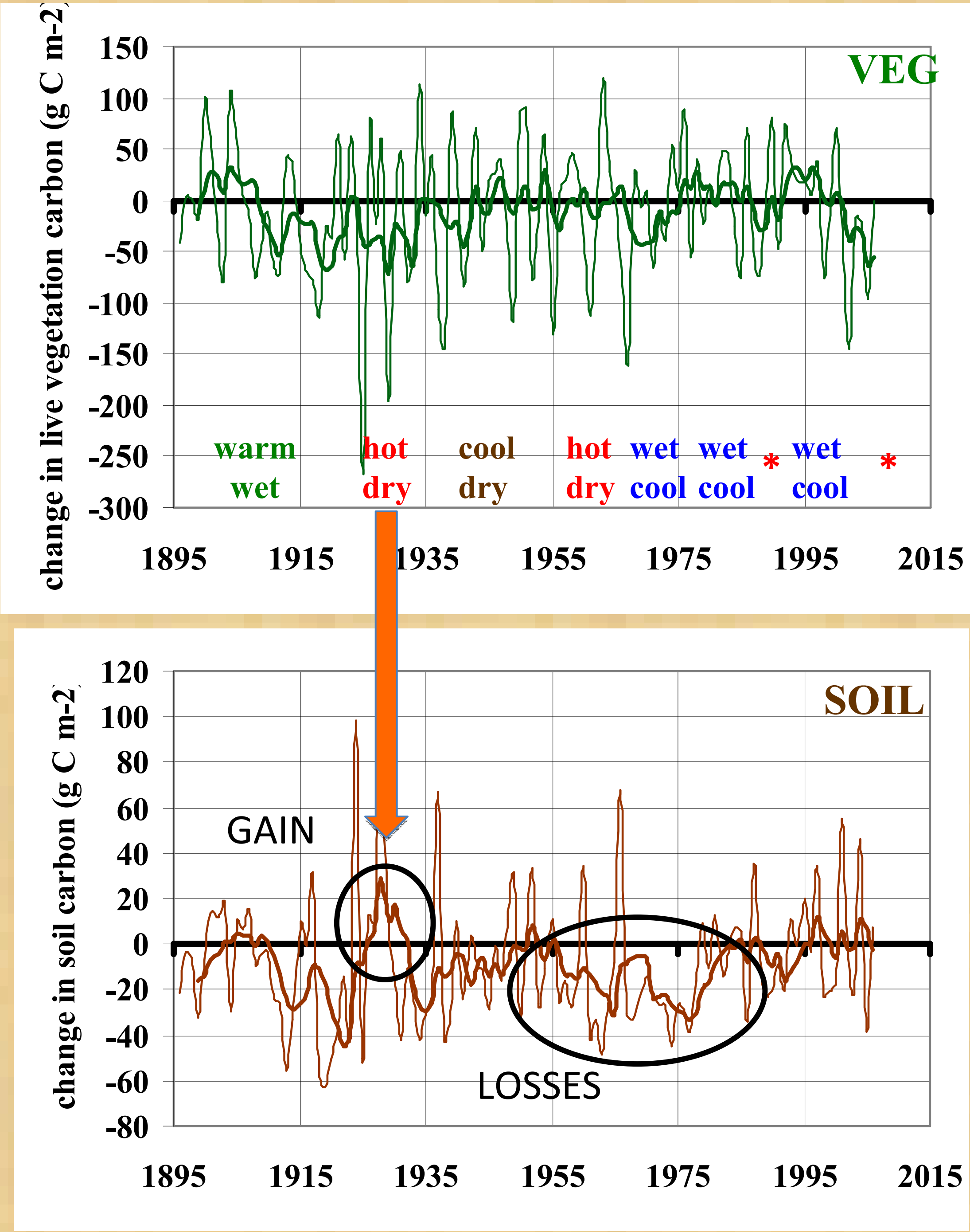


MIROC A2



C sequestration goal in National Parks

source: Dave Conklin, unpu



Response
to climate
signal:
Interannual
variations
in C stocks

vegetation dieback
(litter, fuel)
and/or soil carbon
depletion (reduced
growth and/or
enhanced
decomposition)

Yosemite NP
Conklin unpubl.

Hydrology is key to simulate the future

- Biogeography rules:
  - growing season precipitation (deciduous, evergreen, needleleaf vs broadleaf)
- Plant physiology:
  - transpiration
  - nutrient uptake
- Fire occurrence and effects
  - fuel moisture
  - fire weather

Hydrologic Processes