EMF 2011

Global Climate and Spatial Economic Land Use Models

REDUX

Is it time for the first date?

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A Neophyte (2002) View of Global Climate Change Model Design

- Biophysical processes are central and in fine scale
  - Atmosphere/oceanic/land process interactions
  - Interaction driven by laws of physics
- Human influences are ‘coarsely modeled’
  - Macroeconomic models/data by regions of world (e.g., 12 regions/11 sectors of Image 2.2)
  - Limited behavioral responses

A Neophyte View of Global Climate Change Model Inputs

- Fine detail on physical processes
- Coarse aggregation of socioeconomic phenomena
- Socioeconomic parameters from ‘elsewhere’

A Neophyte View of Global Climate Change Model Outputs

- Changes in atmospheric, oceanic and terrestrial carbon emissions/levels
- World and regional GDP and resulting emissions
- Coarsely disaggregated industrial and agricultural output
- Coarsely disaggregated land use/land cover

Spatial Economic Land Use Models Design

- History
  - "Do roads cause deforestation" analysis
  - Data-poor environments
- Analysis at level of decision making -> implies fine scale (e.g., 30 meter resolution) data
- Behavioral responses are central and explicitly(?) modeled (Socioeconomic services; e.g., access to markets, property rights, prices, assets
- "Location matters"
- Statistical techniques to estimate physical and behavioral parameters

Spatial Economic Land Use Models Outputs

- Relative importance of socioeconomic variables on land use choices – “Do roads cause deforestation?”
- Spatially explicit simulation of land use effects of policy changes
- Fine detail for a small region
- Input into ecological modeling?

Economic Theory

$$R_{hlT} = \int_{t=0}^{\infty} \left(P_{hlT+t} Q_{hlT+t} - \mathbf{C}_{hlT+t} \mathbf{X}_{hlT+t} \right) e^{-i_l t} \, dt$$

Net Present Value of Cost of Discount

Val **effect**

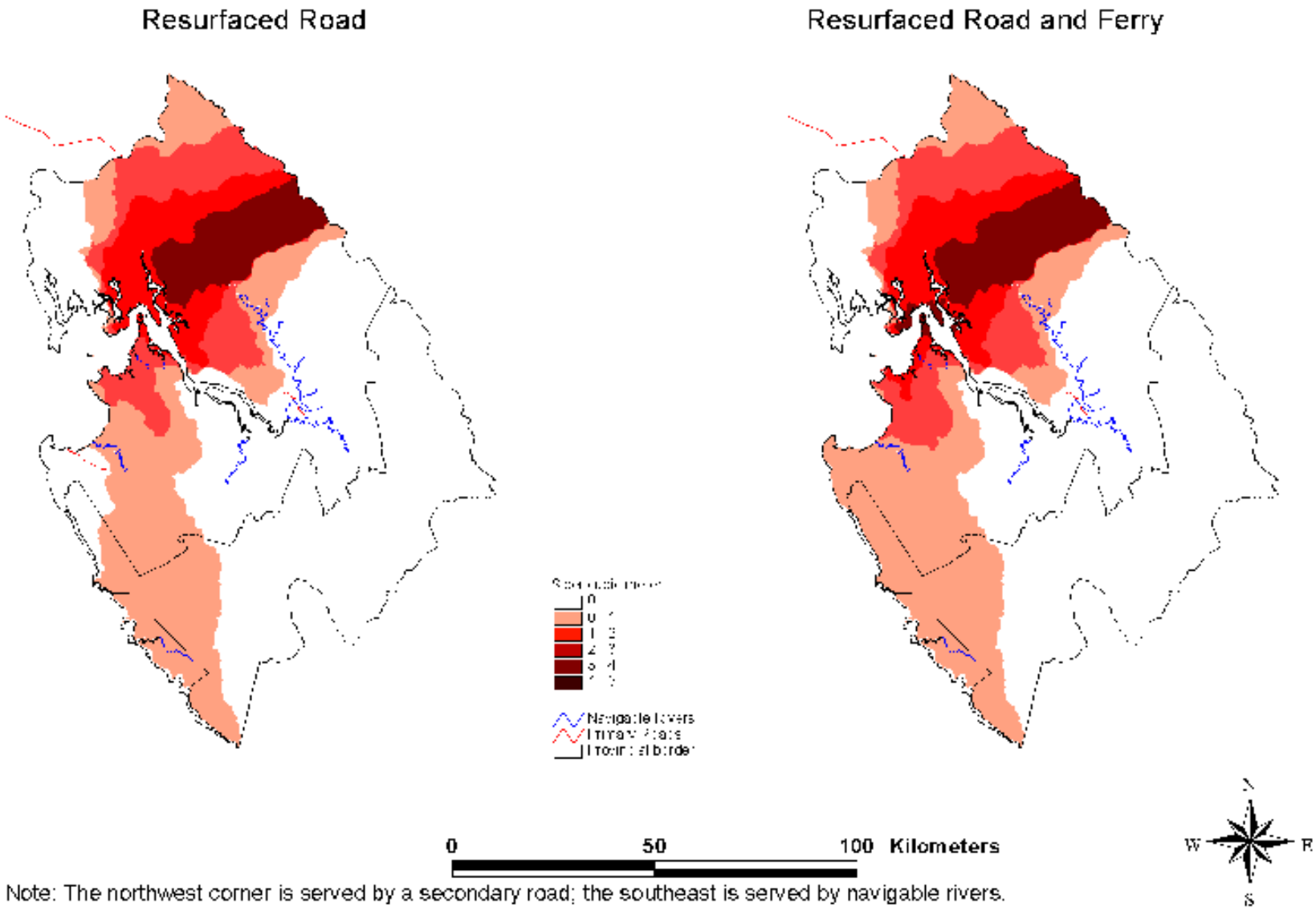
Stuck with spatial variability, not temporal variability, because of bad data!

One calculation for each possible land use h

Choose land use with highest NPV

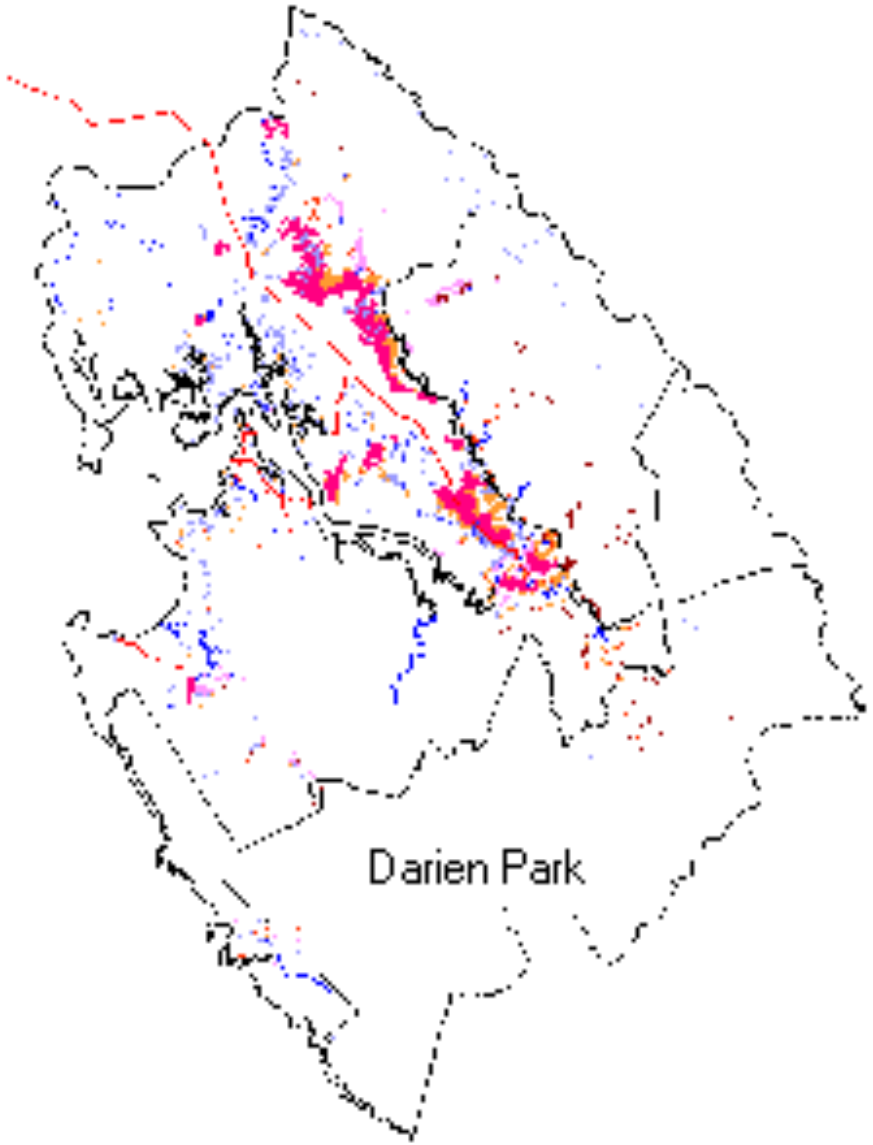
NPV not observable (latent variable)

Change in Transport Cost in Panama from Road Paving



Note: The northwest corner is served by a secondary road; the southeast is served by navigable rivers.

Land Use Change with Road Paving



Some Limitations of Current (2002) Techniques

- Data(!)
- Comparative statics
- Land use transition costs
- Within/without sample issues in simulation

Why Consider Dating?
Climate Change Model View

- Ecosystem changes are fundamentally a local phenomenon - location must be considered explicitly
- Location-specific land use changes could feed back into climate change effects

Why Consider Dating?
Spatial Economic Modeling View

- Global, high-resolution land use/land cover data sets are becoming available
- Technology for spatial economic modeling of larger areas exists/being developed
- Need simulation results from global economic/environmental models
  - Geophysical – temperature, rainfall
  - Socioeconomic – effects of WTO, Kyoto on local economic variables

Where to go on the first date?

- Choose a couple of regions of the world where…
  - Data availability reasonably good
  - Of special interest
  - Can piggyback on other data collection/research efforts
- Candidates?
  - Southern Africa
  - Amazon River Basin
  - Central America
  - Midwest of US, central Europe, central China

FAST-FORWARD TO 2011

Food Security, Farming, and Climate Change to 2050

Scenarios, Results, Policy Options

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May 2, 2011

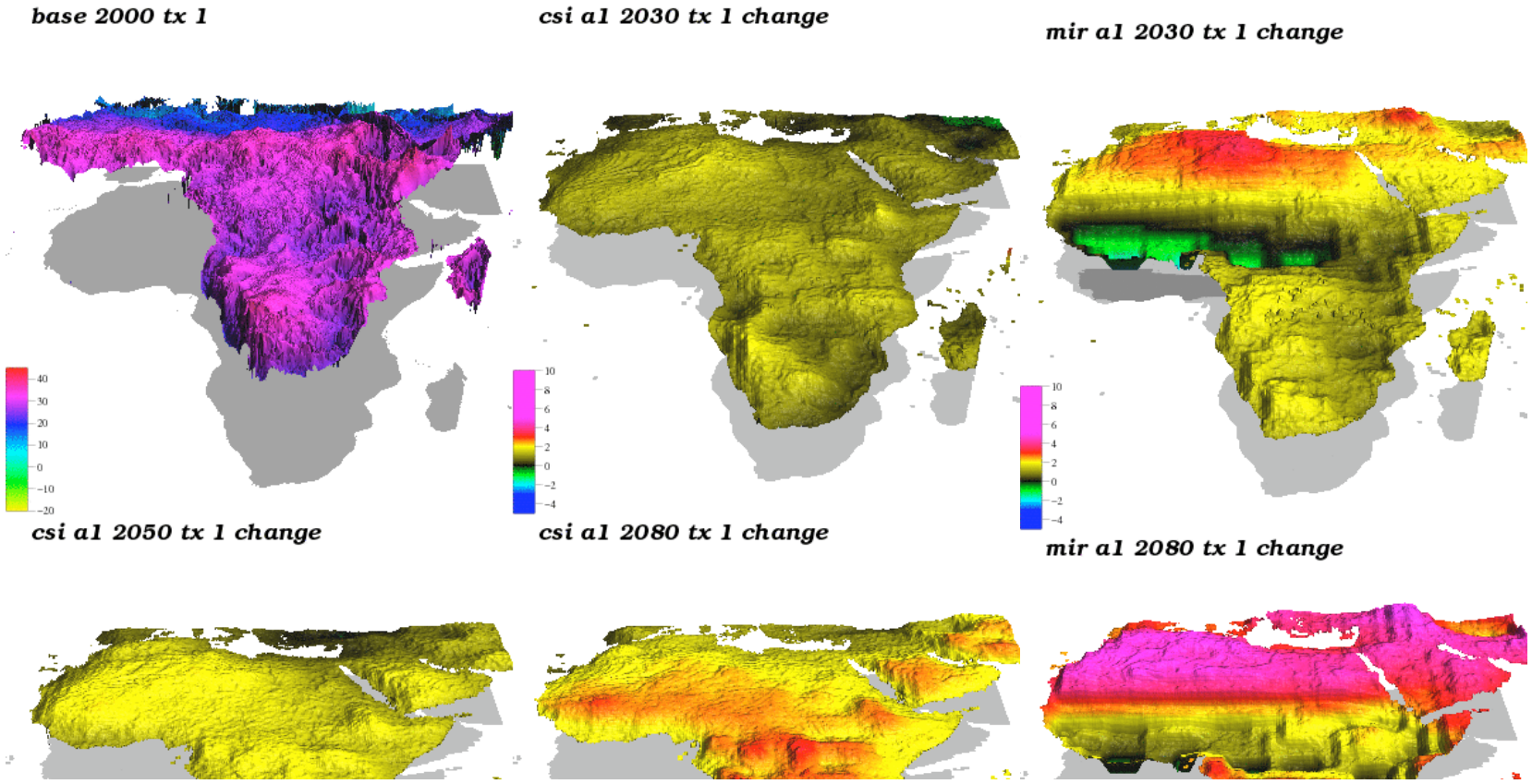
Global Change Model Components

- GCM climate scenarios
- DSSAT crop modeling suite
  - Biophysical crop response to temp and precipitation at 5 arc minute resolution (10 km pixels at equator)
- IFPRI Spatial Allocation Model – SPAM
  - Spatial distribution of crops based on crop calendars, soil characteristics, climate of 20 most important crops
- IMPACT
  - Global food supply demand trade model. Results to 2050 with global hydrology and crop model results

GCM Temperature Results Vary

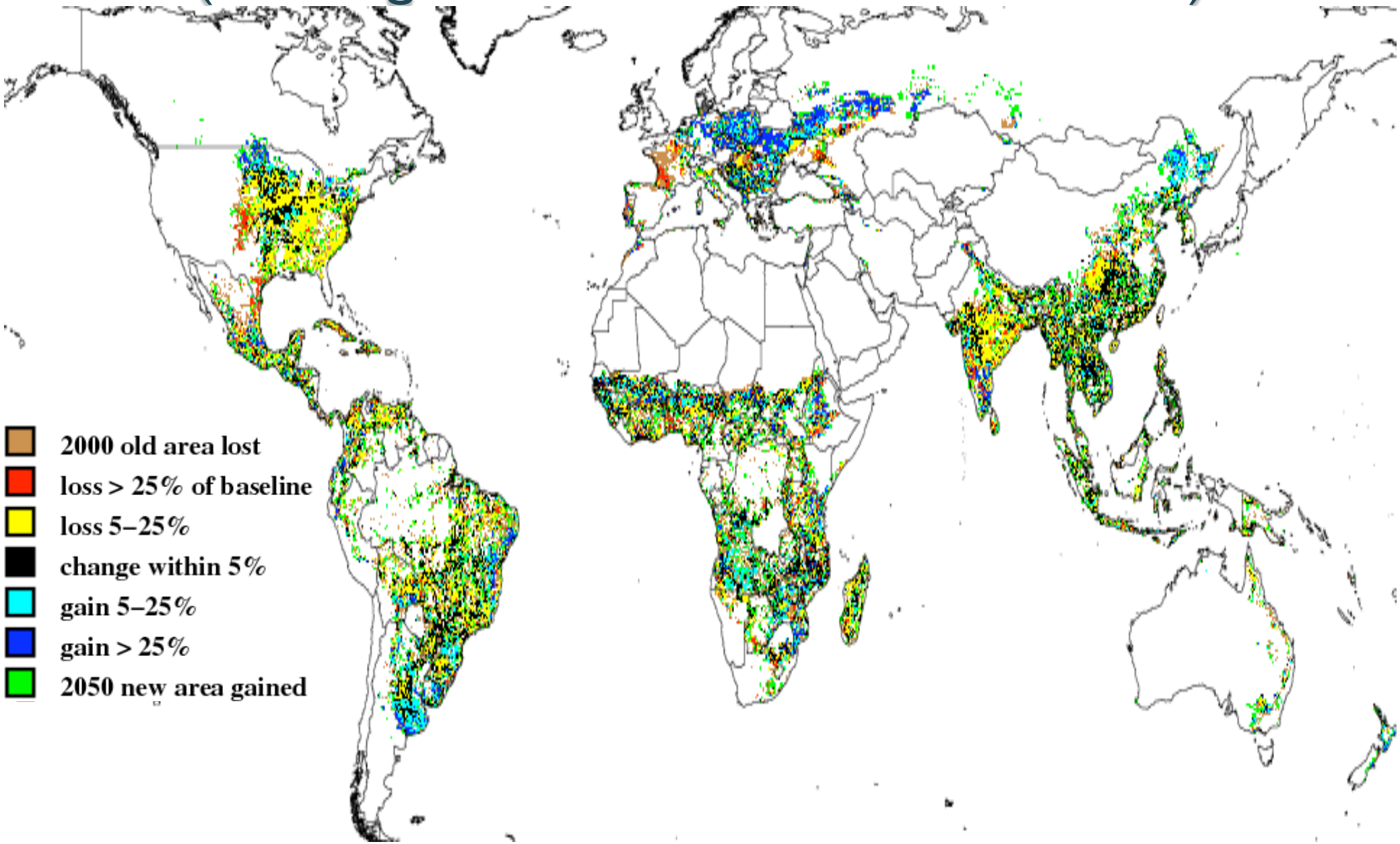
monthly maximum temp change scenarios, MIROC and CSIRO GCMs

2000	2000-2030 change, CSIRO A1B	2000-2030 change, MIROC A1B

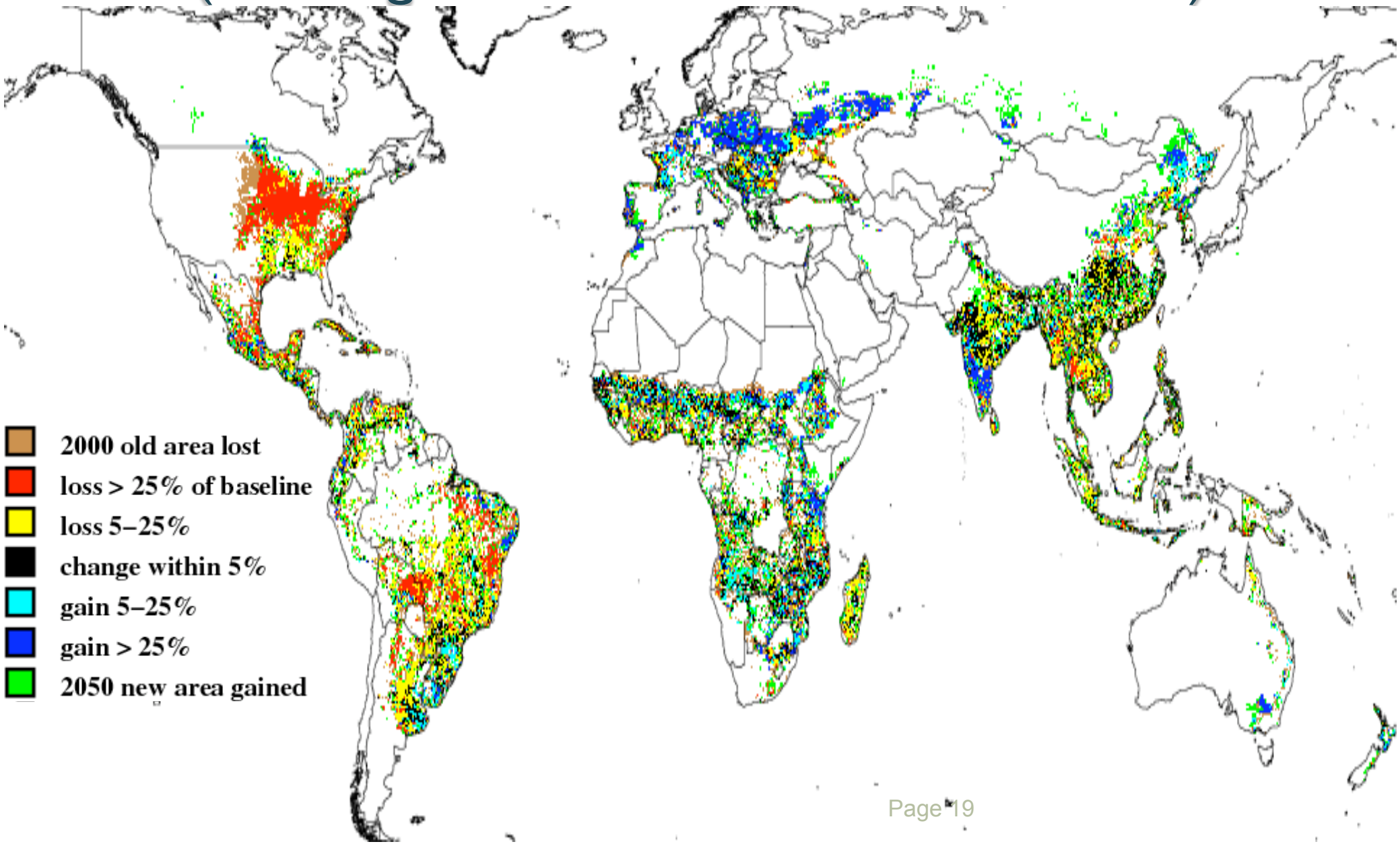


See http://www.ifpri.org/book-775/climate-change/mapindex for animations of different regions

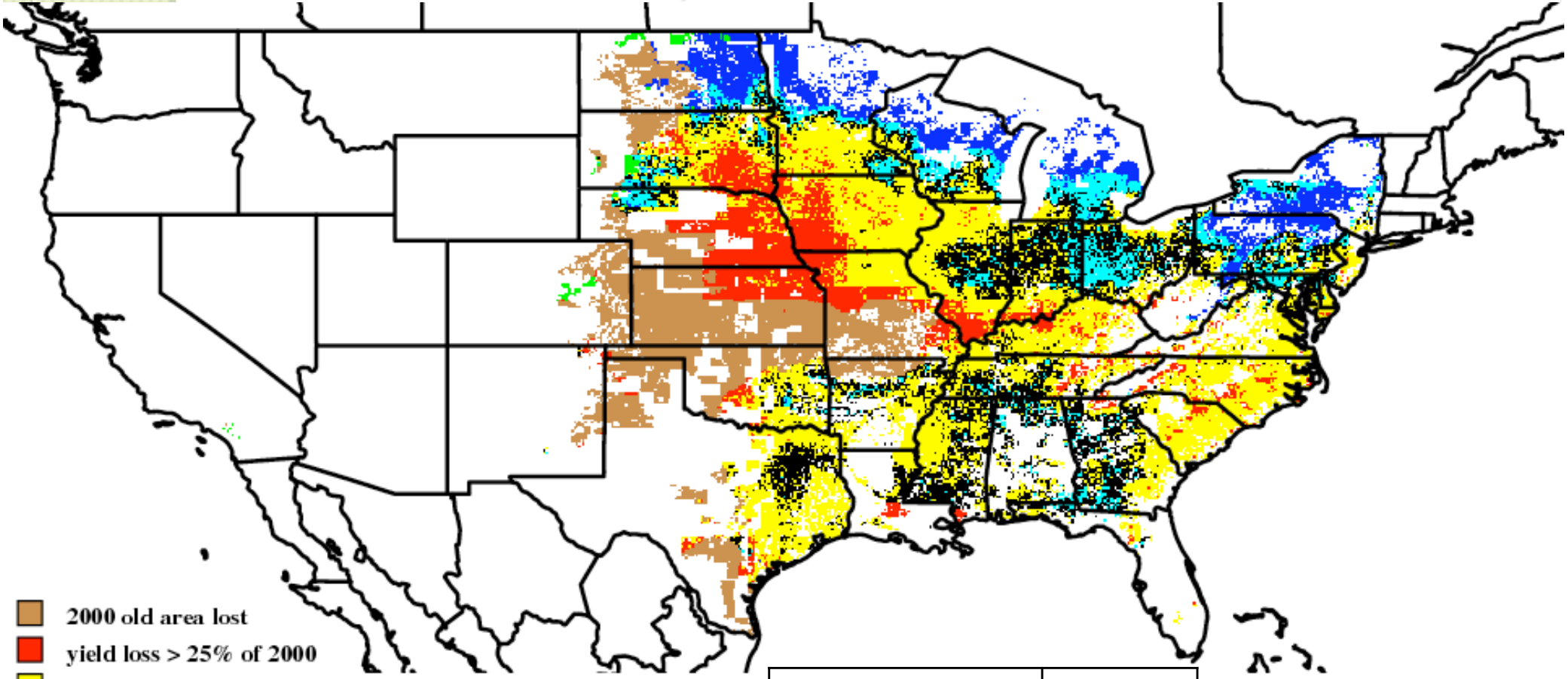
Yield Effects, Rainfed Maize, *CSIRO* A1B (% change 2000 climate to 2050 climate)



Yield Effects, Rainfed Maize, *MIROC* A1B (% change 2000 climate to 2050 climate)

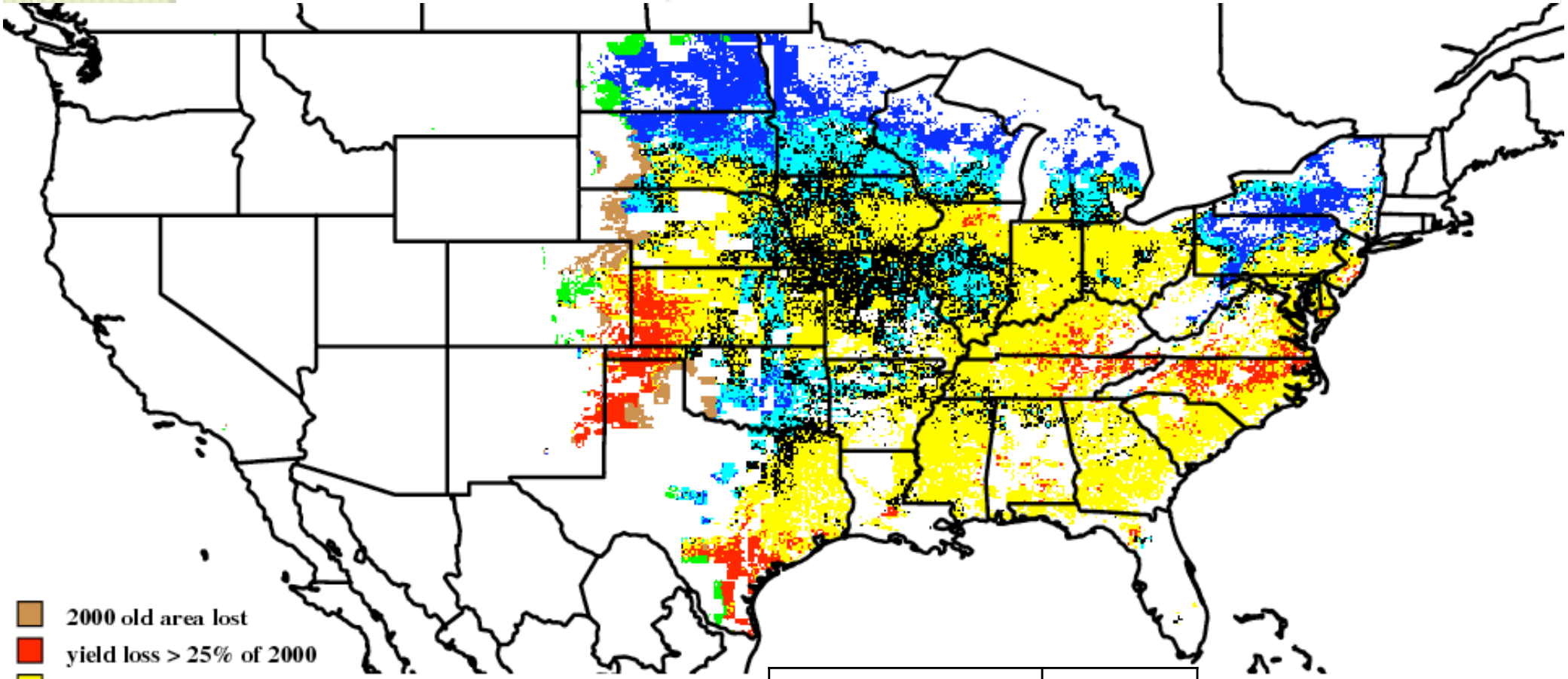


Corn Yield Change, 2000-2050 (%)
CNR GCM, A1 GHG Scenario



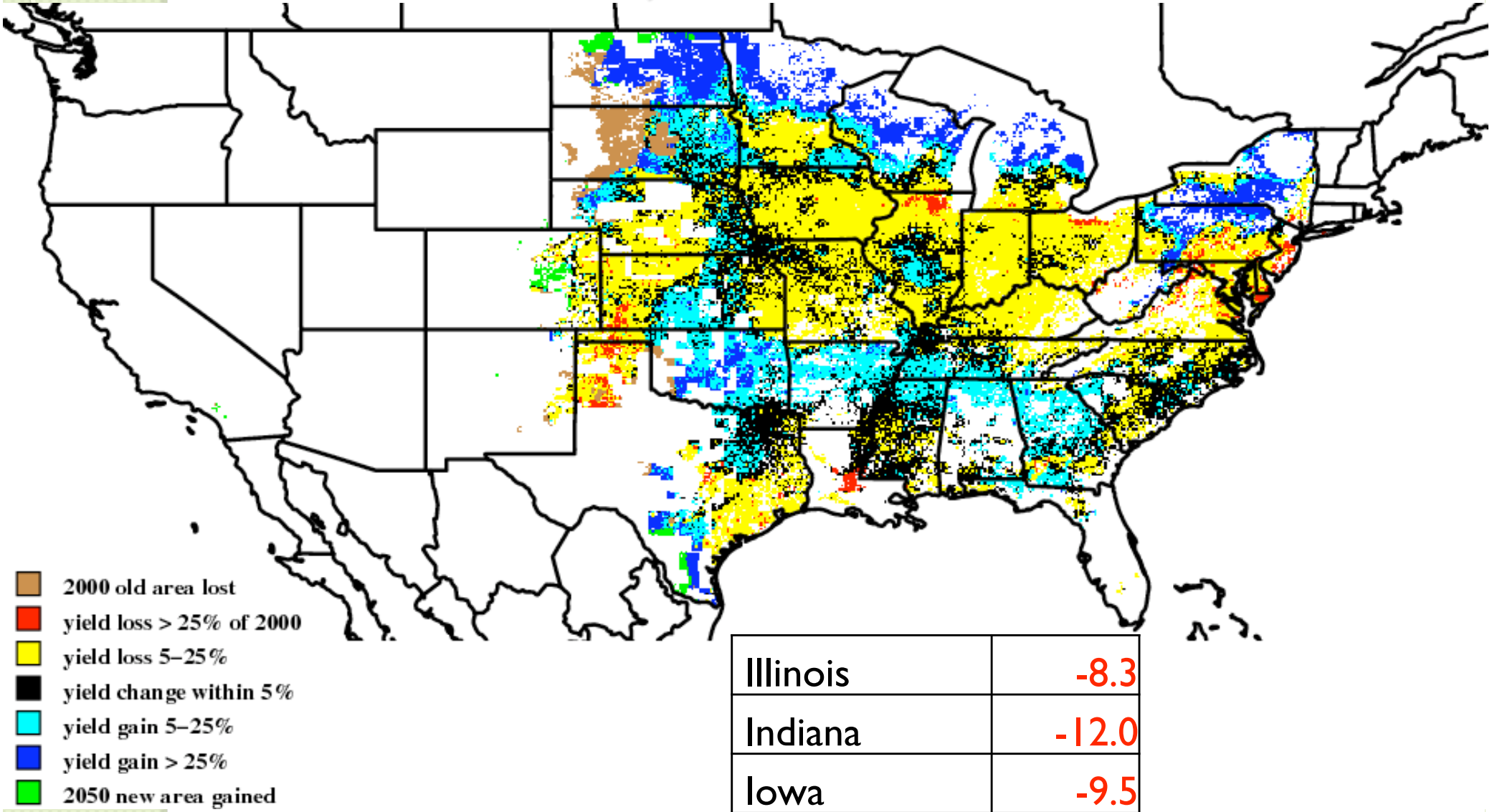
Illinois	-10.1
Indiana	-4.1
Iowa	-21.3
Minnesota	-10.4
Ohio	2.2

Corn Yield Change, 2000-2050 (%)
CSI GCM, A1 GHG Scenario



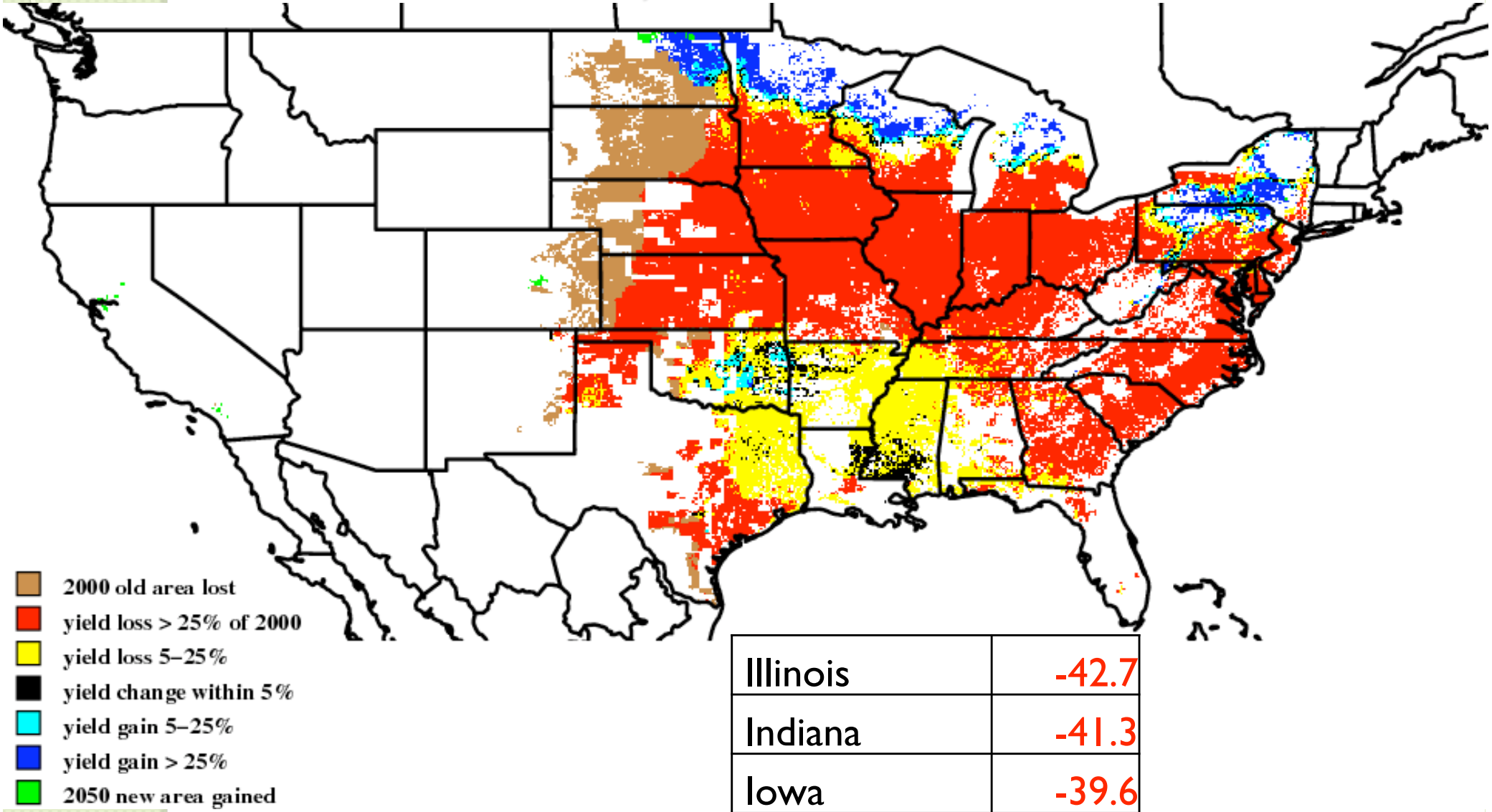
Illinois	-5.9
Indiana	-12.1
Iowa	-3.6
Minnesota	12.1
Ohio	-10.3

Corn Yield Change, 2000-2050 (%)
ECH GCM, A1 GHG Scenario

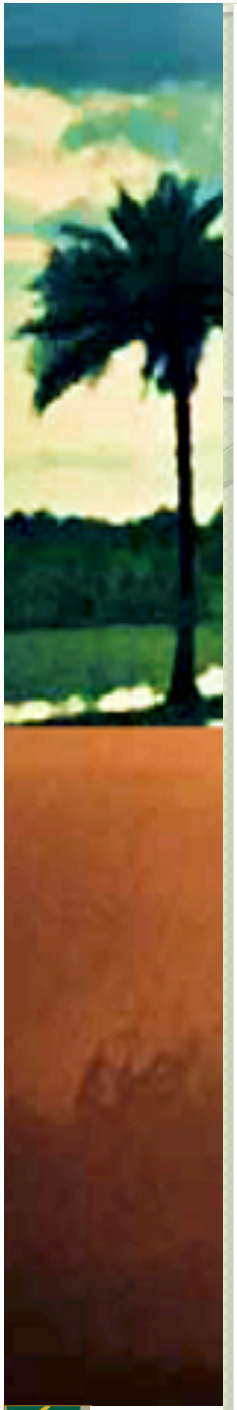


Illinois	-8.3
Indiana	-12.0
Iowa	-9.5
Minnesota	-0.9
Ohio	-12.0

Corn Yield Change, 2000-2050 (%)
MIR GCM, A1 GHG Scenario



Illinois	-42.7
Indiana	-41.3
Iowa	-39.6
Minnesota	-30.5
Ohio	-43.1



Overall scenarios

Plausible futures for population and GDP growth

- Optimistic
  - High GDP and low population growth
- Baseline
  - Medium GDP and medium population growth
- Pessimistic
  - Low GDP and high population growth

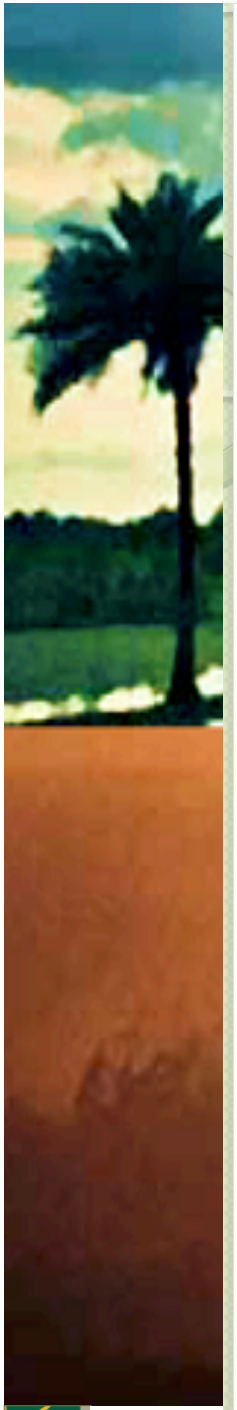
Three global and regional GDP per-capita growth scenarios

Global growth rate assumptions, annual average 2010-2050 (%)

	Pessimistic	Baseline	Optimistic
Population	1.04	0.70	0.35
GDP	1.91	3.21	3.58
GDP per capita	**0.86**	**2.49**	**3.22**

African GDP per capita growth rate assumptions, annual average 2010-2050 (%)

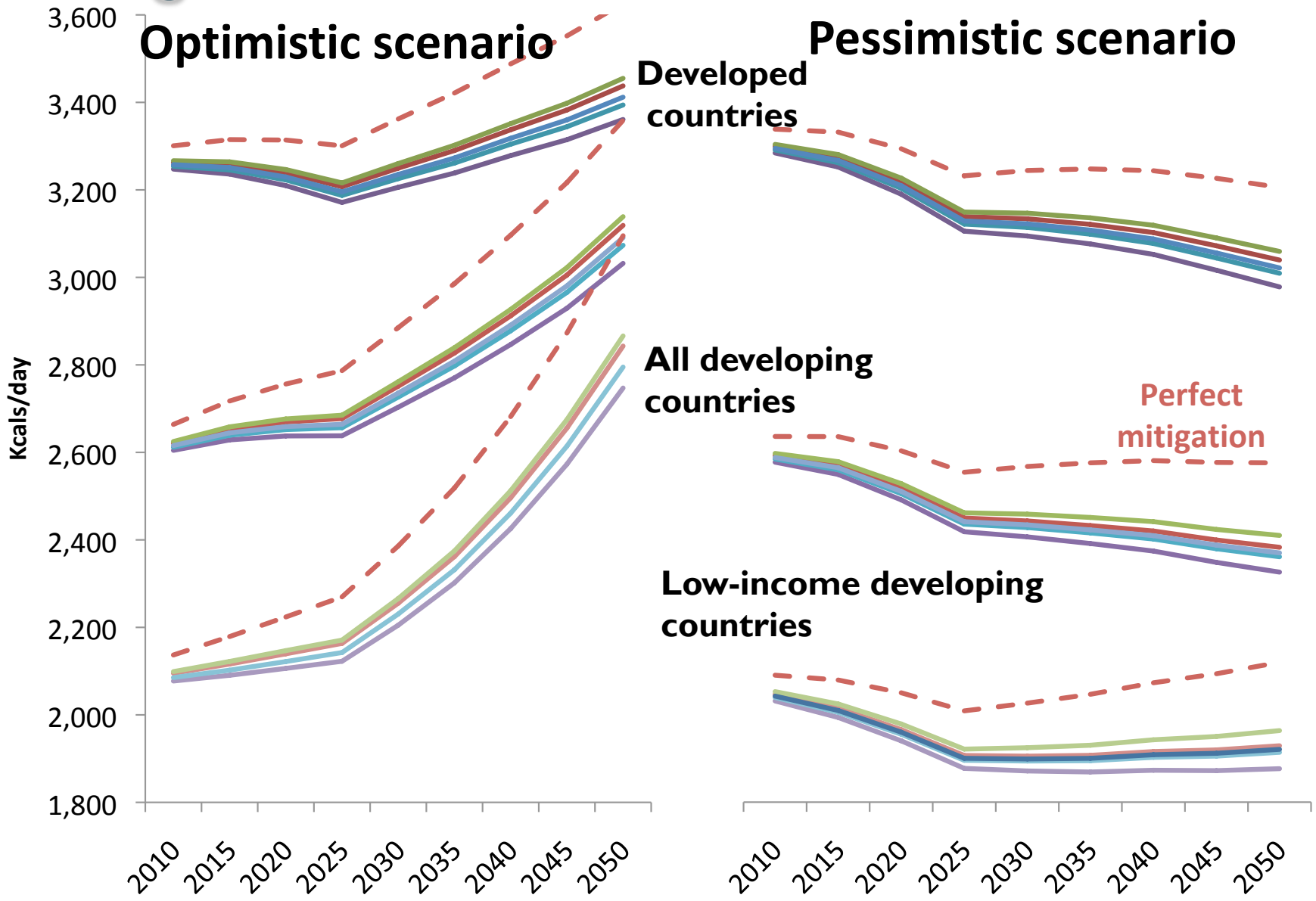
	Pessimistic	Baseline	Optimistic
Central Africa	2.42	3.92	4.85
Western Africa	2.04	3.63	4.03
Eastern Africa	2.72	4.18	4.97
Northern Africa	1.78	2.60	3.49
Southern Africa	0.55	2.98	3.44



Five climate scenarios

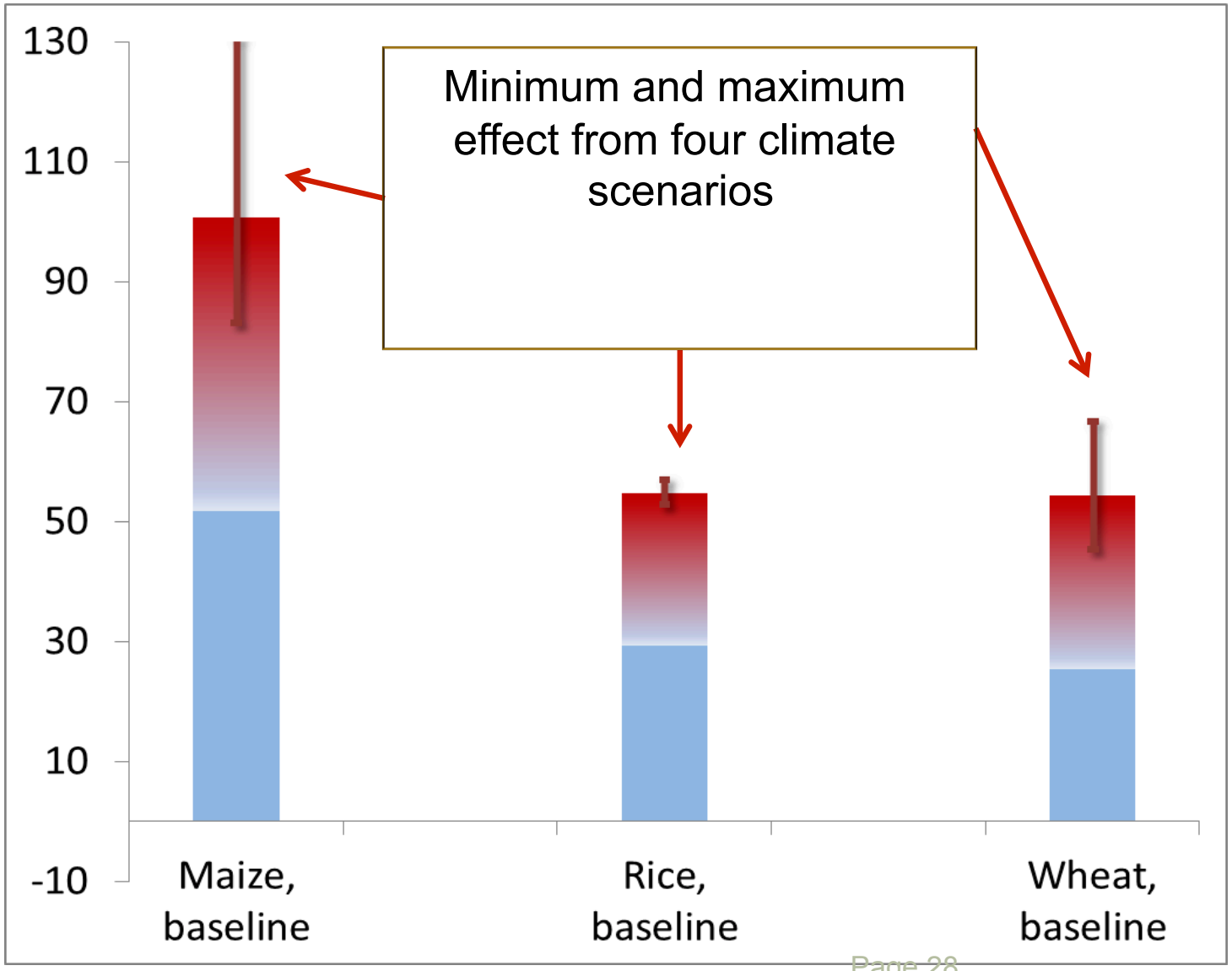
- Climate scientists "All scenarios have equal probability."
- Our modeling approach, for each overall scenario, use climate scenarios from…
  - Two GCMs – MIROC (Japanese) and CSIRO (Australian)
  - Two SRES scenarios – A1B and B1
  - Perfect mitigation

Assessing food security and climate change outcomes

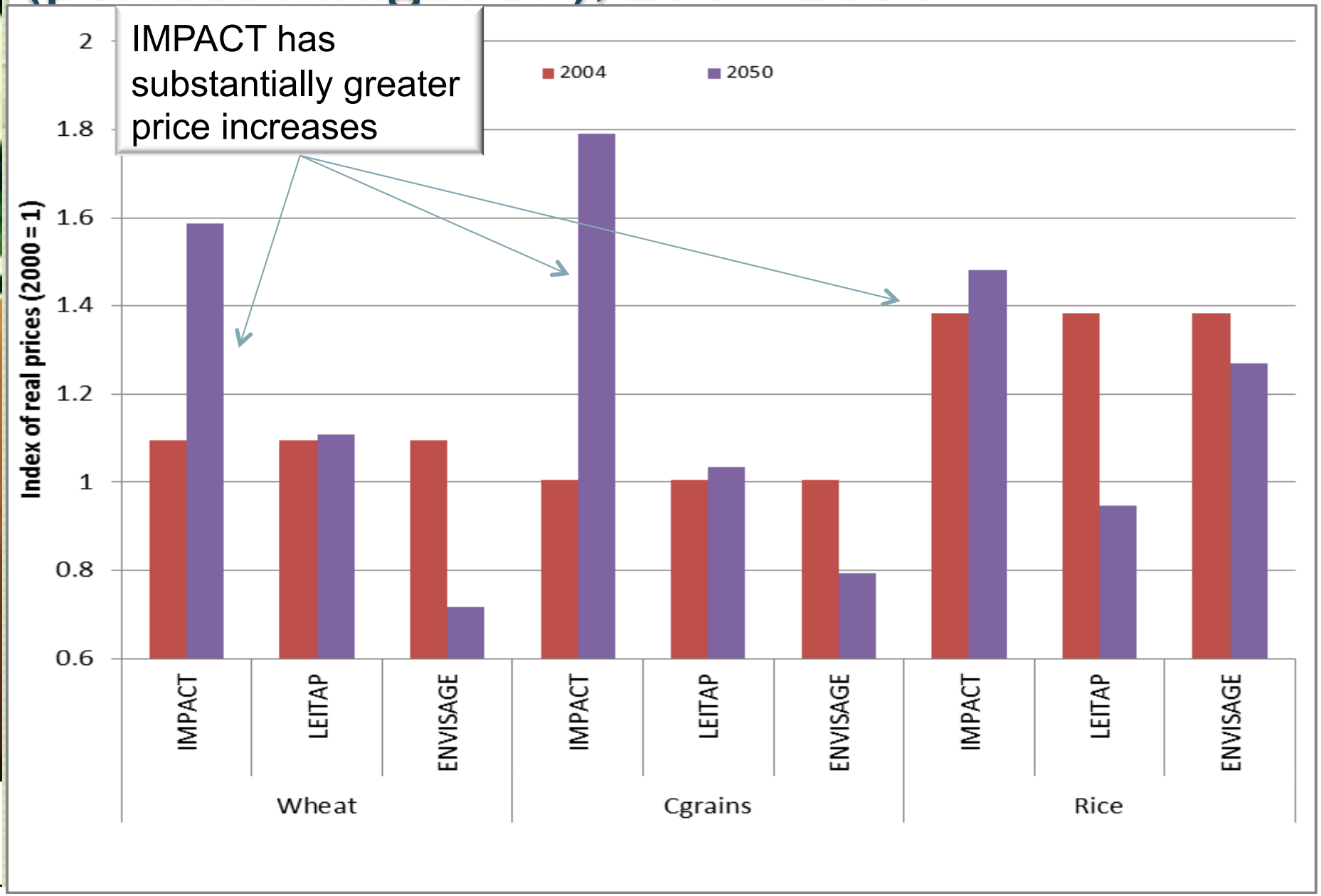


Climate change scenario effects differ

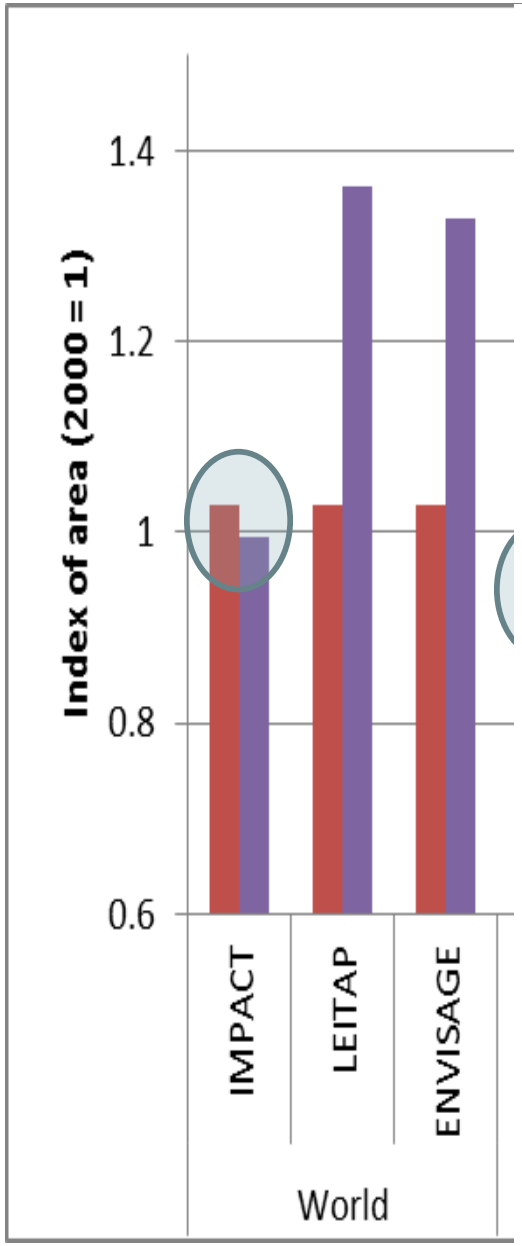
(price increase (%), 2010 – 2050, Baseline economy and demography)



Alternate Perspectives on Price Scenarios (perfect mitigation), 2004-2050



Alternate perspectives on agricultural area changes, 2004-2050



IMPACT Area Response, at FPU Level

$$A_{tni} = \alpha_{tni} \times (PS_{tni})^{\varepsilon_{iin}} \times \prod_{j \neq i} (PS_{tnj})^{\varepsilon_{ijn}} \times (1 + ga_{tni}) - \Delta A_{tni}\left(WAT_{tni}\right);$$

A_{tni} = crop area

α = crop area intercept

PS_{tni} = producer price

ε = area price elasticity

WAT_{tni} = water stress

ga_{tni} = exogenous area growth rate

Selected CGE Area Supply Functions

- Envisage (World Bank/FAO)

$$S = \frac{\overline{S}}{1 + \beta e^{-\varepsilon P}}$$

- LEITAP (Wageningen)

$$S = \overline{S} - \beta P^{-\varepsilon}$$

- $\overline{S}$ - Asymptote
- ε - Price elasticity

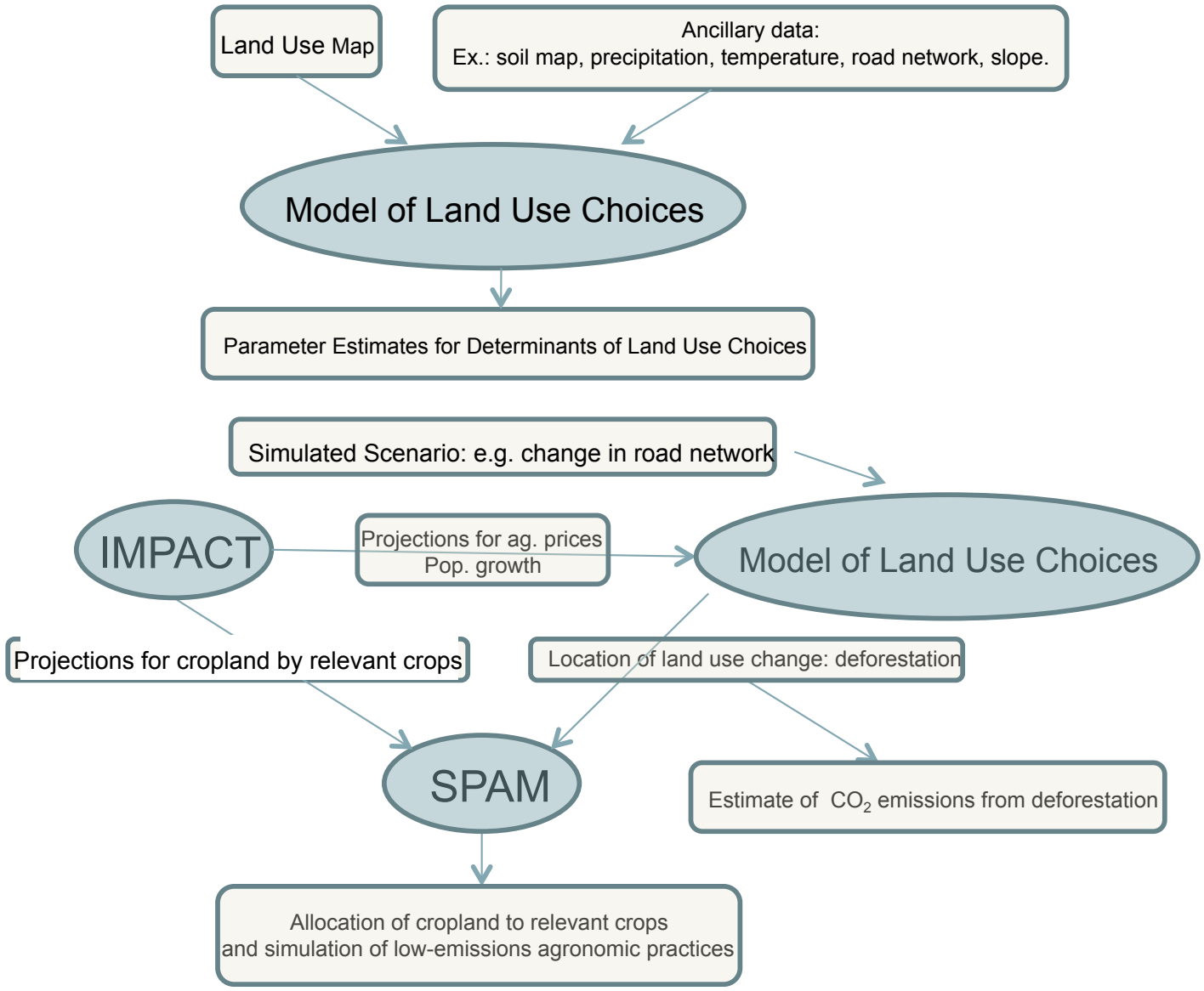
Aggregate land supply parameters for ENVISAGE and LEITAP

Ratio of all land rated very suitable, suitable, moderately suitable land and marginally suitable land to actual arable land in use

	Expansion potential		Initial supply elasticity	
	ENVISAGE	LEITAP	ENVISAGE	LEITAP
China	1.298	1.174	0.250	0.100
India	1.145	1.050	0.250	2.317
Canada	2.446	7.870	1.000	1.384
United States	2.244	1.843	1.000	1.384
Brazil	8.657	3.045	1.000	2.000
Russia	2.383	4.461	1.000	0.902
Sub-Saharan Africa	5.624	1.893	1.000	1.162
EU27 & EFTA	2.019	1.149	0.250	0.170
Middle East & North Africa	1.079	1.020	0.250	0.000
Australia & New Zealand	3.149	1.380	1.000	0.115
High income countries	2.109	1.442	0.472	0.494
Developing countries	2.410	1.698	0.537	1.316
East Asia & Pacific	1.651	1.891	0.554	0.557
Europe & Central Asia	1.896	2.800	1.000	0.968
LAC less Brazil and Mexico	8.719	2.017	1.000	1.410
World total	2.288	1.594	0.511	0.982

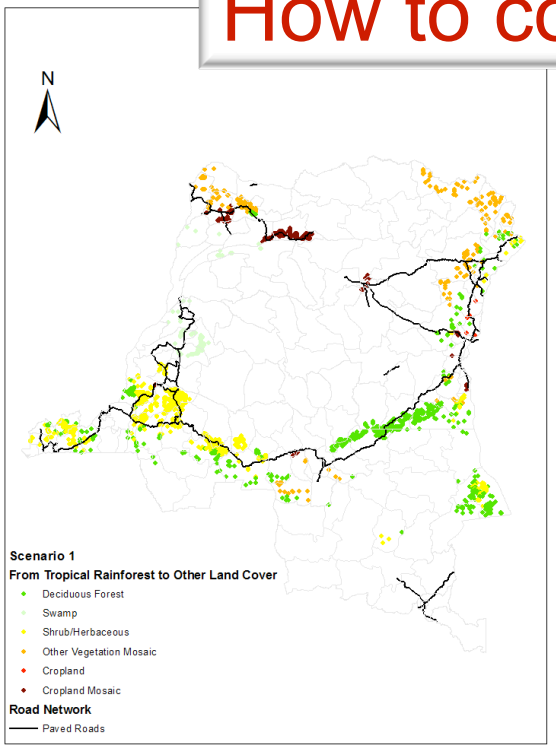
PLANNED CHANGES TO IMPACT LAND USE CHANGE MODELING

Models Currently Working as Separate Entities Can Work Together

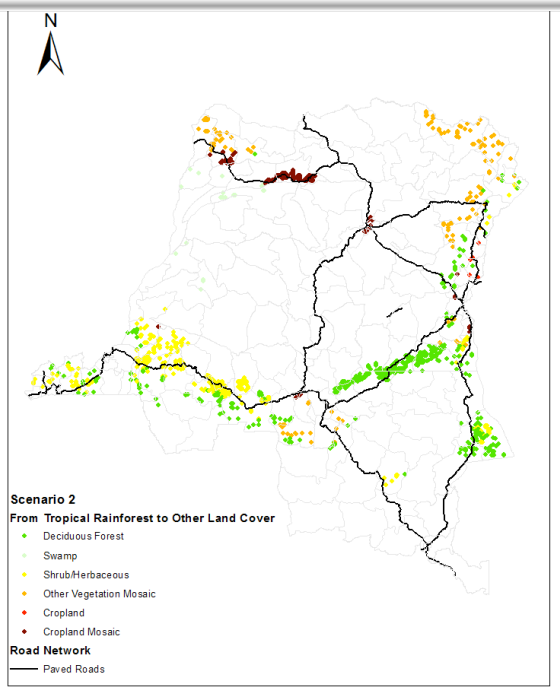


DRC Road Network Expansion Scenarios and Change in Forested Land

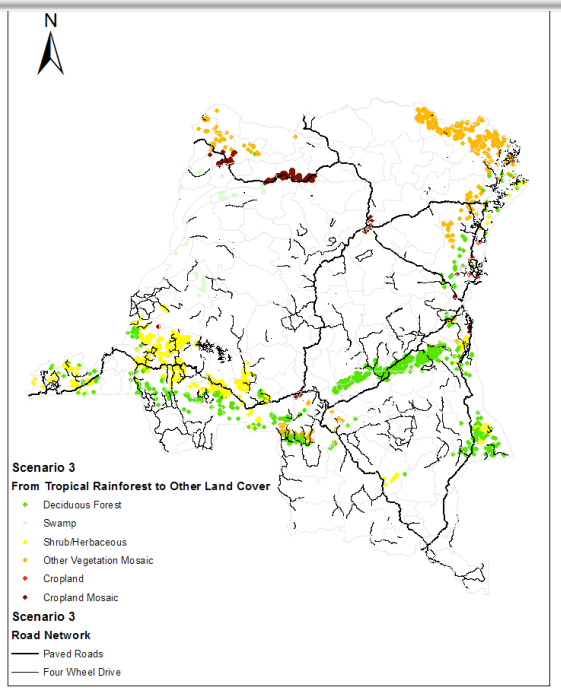
How to construct road expansion scenarios???



Road Network expansion Scenario 1



Road Network expansion Scenario 2



Road Network expansion Scenario 3