# *Land Use Scenarios for the U.S.: Interpreting Global Storylines for National-Scale Assessments*

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Snowmass 2013

# Current Project Team

- Britta Bierwagen, Phil Morefield, U.S. EPA ORD/ NCEA
- David Theobald, Conservation Science Partners
- Philip Groth, Anne Choate, ICF International
- Alicia Barnash, Angelica Murdukhayeva, Jonathan Witt, ORISE Fellows

# ICLUS: Integrated Climate and Land Use Scenarios

## Why develop these scenarios?

- Assess impacts to EPA-specific endpoints
  - Air and water quality, aquatic ecosystems, human health
  - Inform Agency decision making
- Need nationwide coverage
  - Consistency with emissions storylines to integrate with climate change assessment
  - Set of scenarios to explore range of potential impacts




Report: http://www.epa.gov/ncea/global/iclus

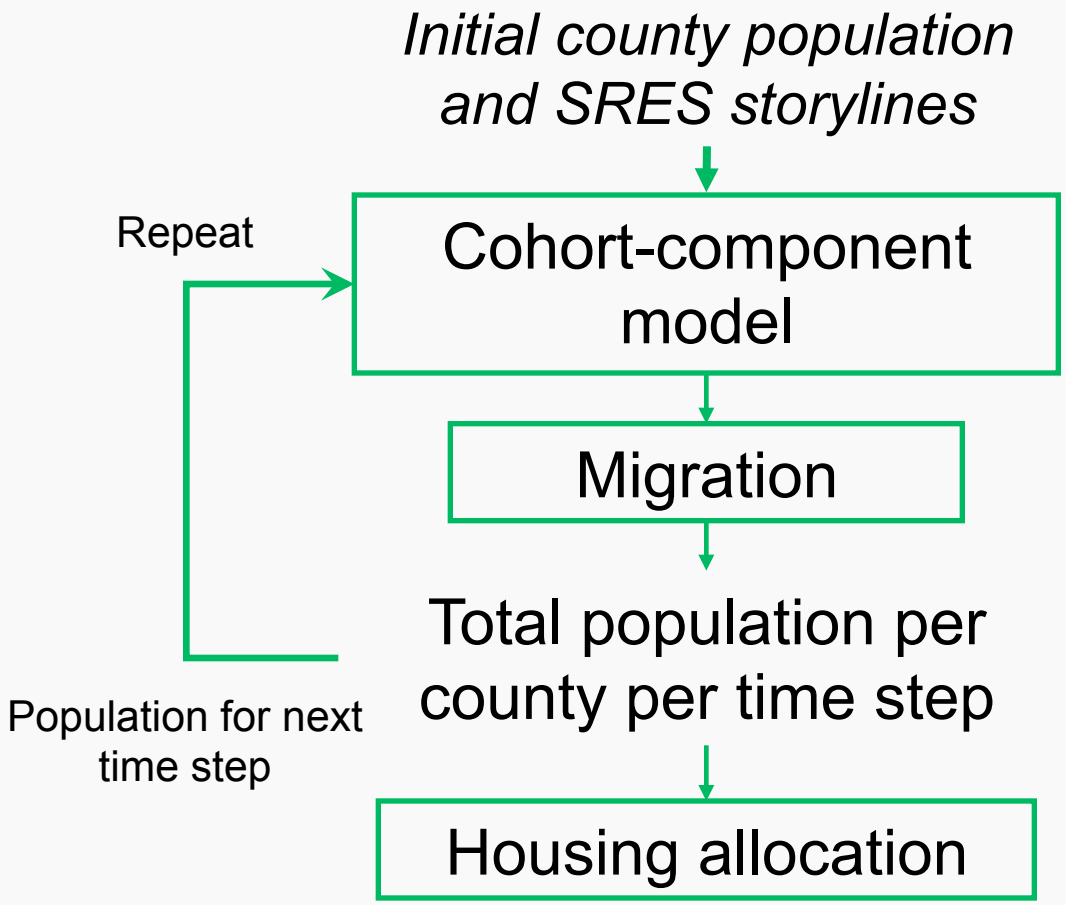
# Broader Challenges

- Scenarios
  - Interpreting global storylines into nationally-relevant ones
  - Quantifying storylines for model inputs
- Consistency
  - Comparisons to land-use change models
  - Measurements of consistency?
- Feedbacks
  - Climate influences on model components
  - Biophysical effects of land use changes on climate system

# Presentation Overview

- What is ICLUS?
- Applications using ICLUS
- Further ICLUS development
  - New scenarios
  - Opportunities for consistency and comparisons
- Feedbacks and opportunities to explore diverse mitigation and adaptation options

# ICLUS Conceptual Diagram



# ICLUS v1

## Amenity Information for Gravity Model for each county

- Mean temperature for January, 1941-70
- Mean hours of sunlight for January, 1941-70
- Mean temperature for July, 1941-70
- Mean relative humidity for July, 1941-70
- Percent water area
- Held constant across scenarios, through time

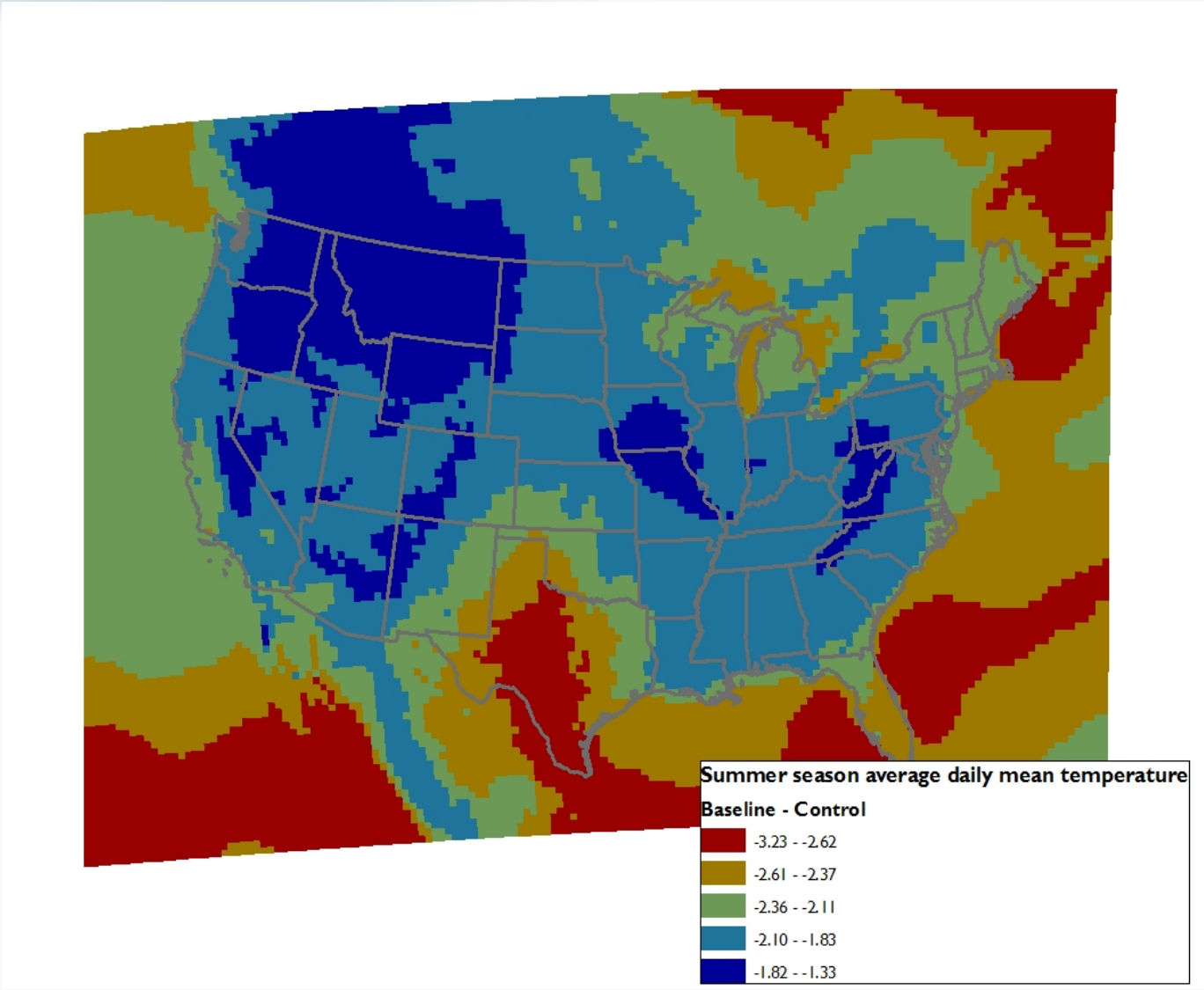


USDA dataset, McGranahan, 1999

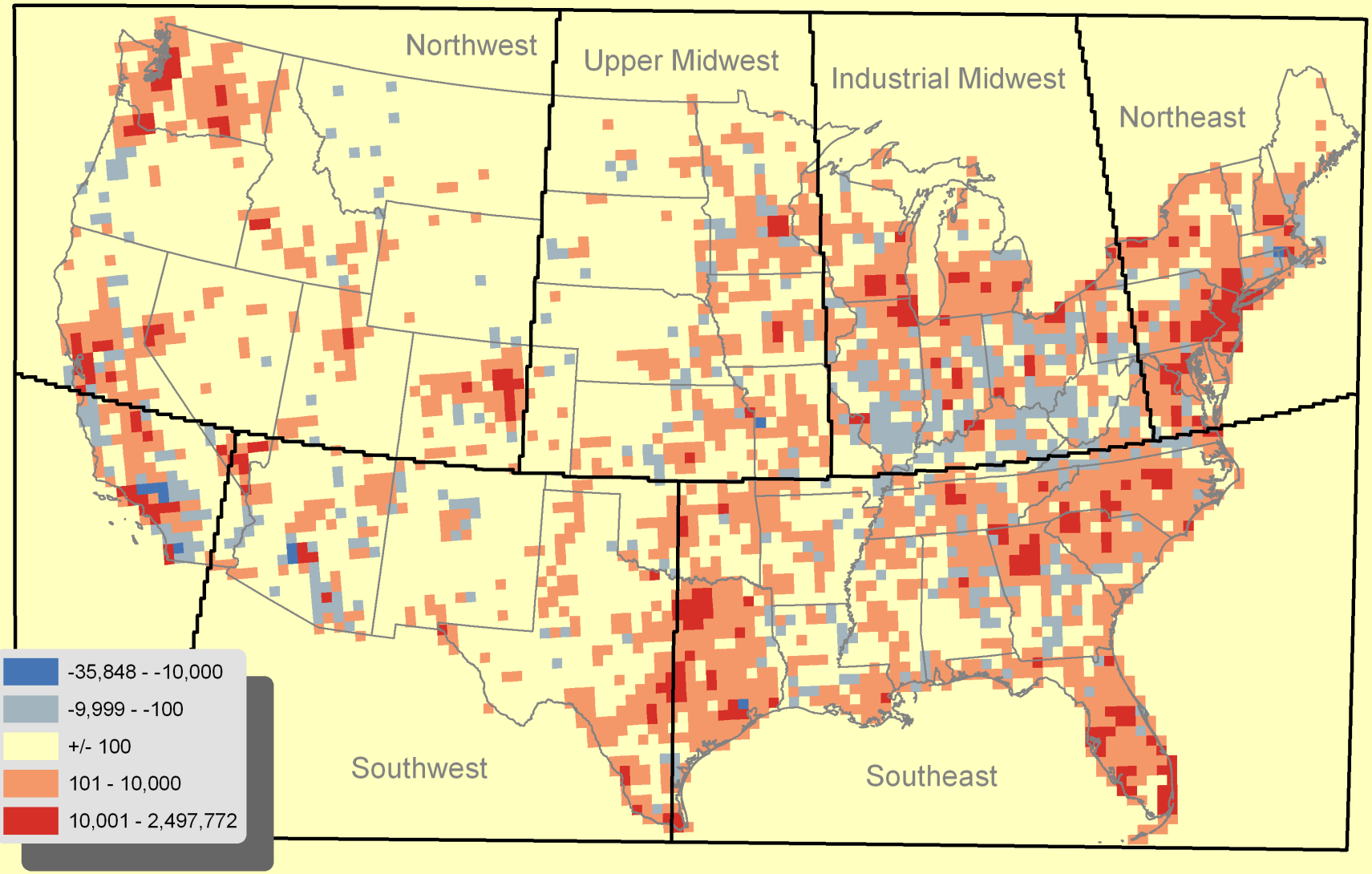
# Example Applications

- Heat-related mortality (Voorhees et al. 2011, ES&T)
  - Greater number of older, heat-sensitive individuals in areas with larger temperature increases
  - Impacts not apparent by only examining greatest temperature change or scenario with highest population growth
- Stormwater runoff
  - Policy analysis of impervious surface cover changes for stormwater runoff
- 20 watersheds
  - Effects of land use and climate change on water quality

# CMAQ-Projected 2050 Temperature: Difference between Baseline and Control



# 50+ Population Map: A1 minus A2 (36km cells)
# 2050



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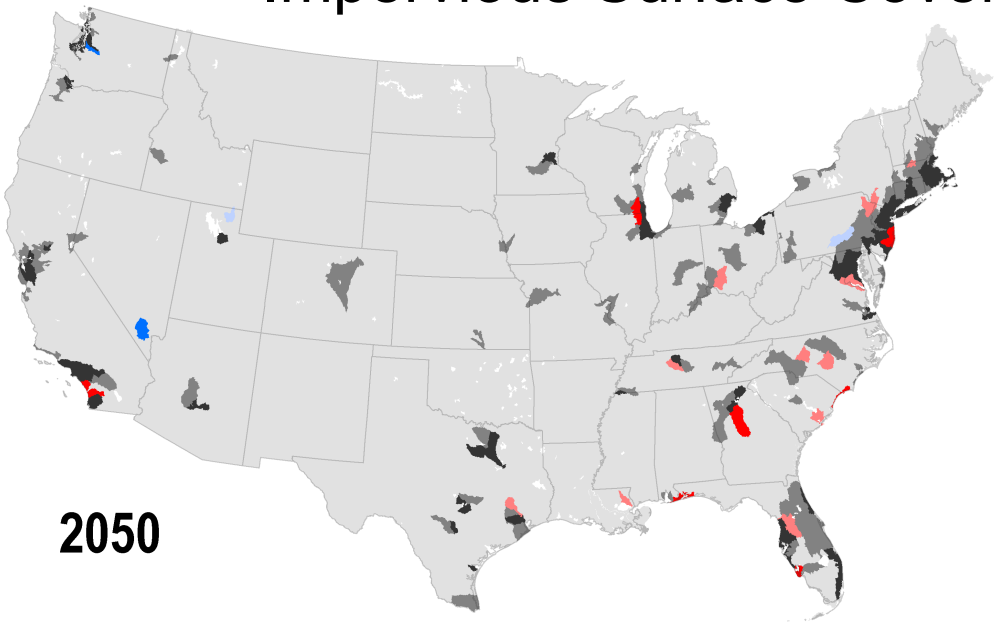
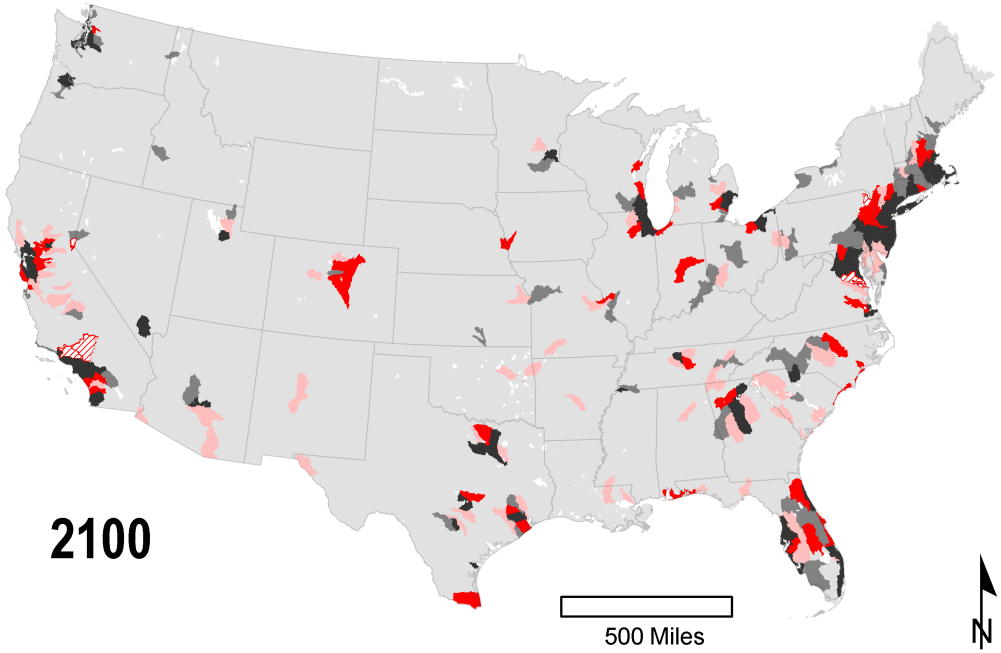
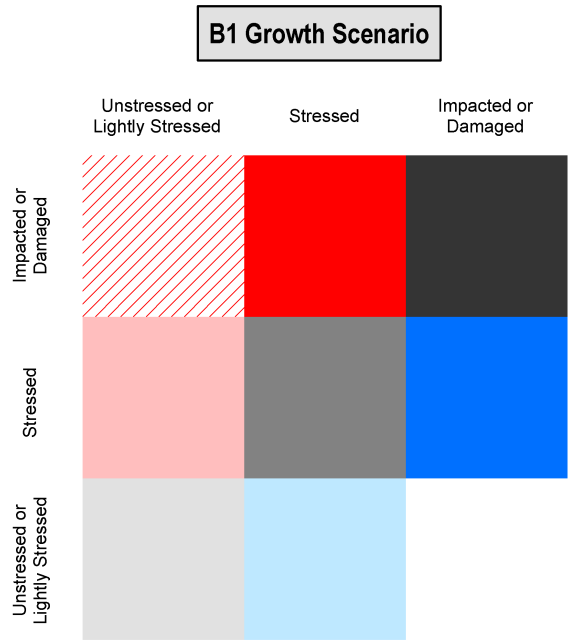
# Impervious Surface Cover – HUC 8




A2 Growth Scenario




**Unstressed: <1% impervious**

**Lightly Stressed: 1 - 5% impervious**

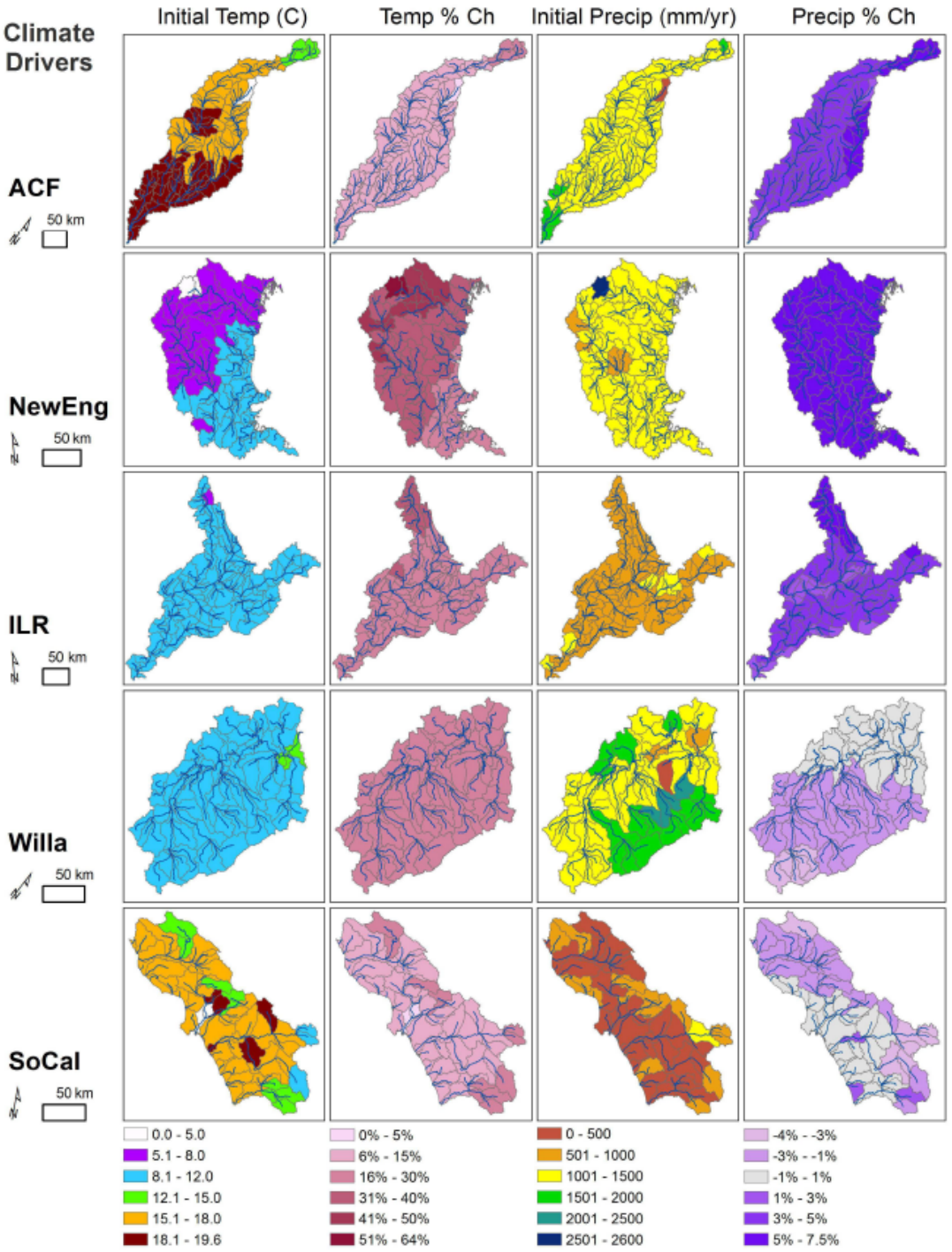
**Stressed: >5 - 10% impervious**

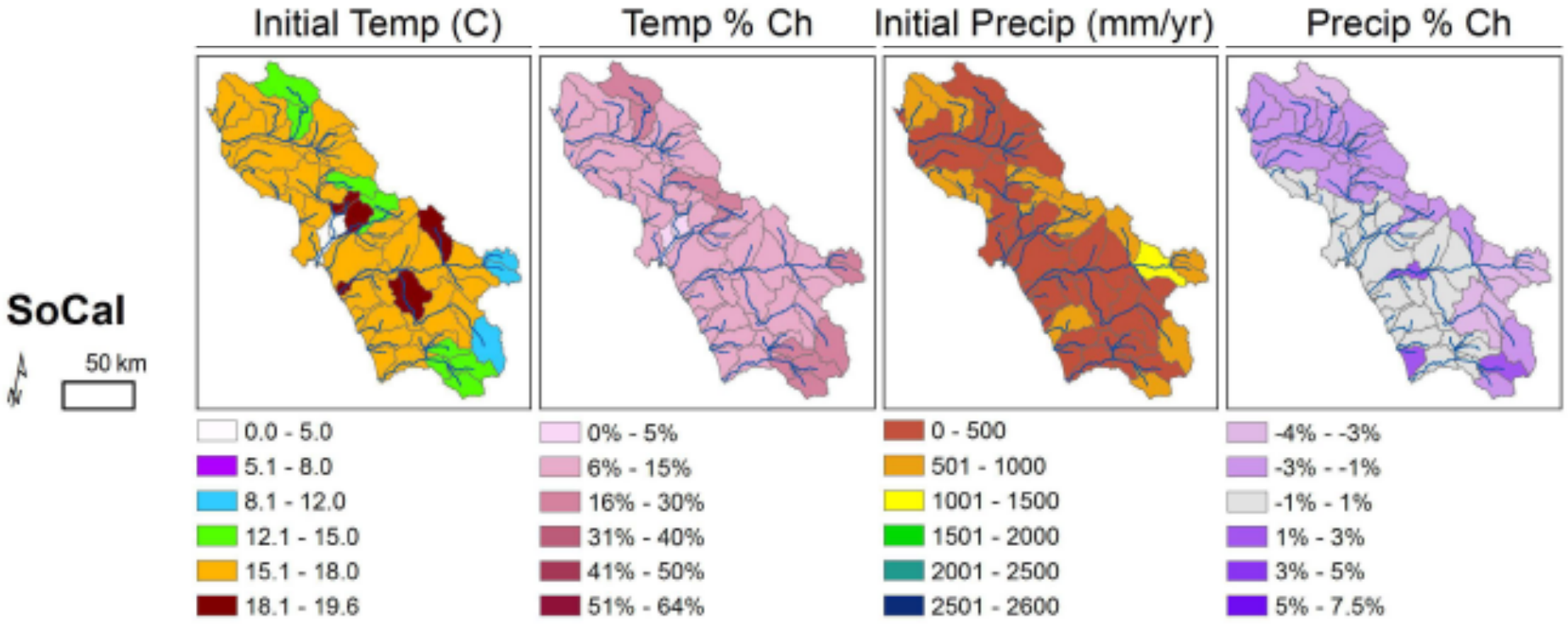
**Impacted: >10 - 25% impervious**

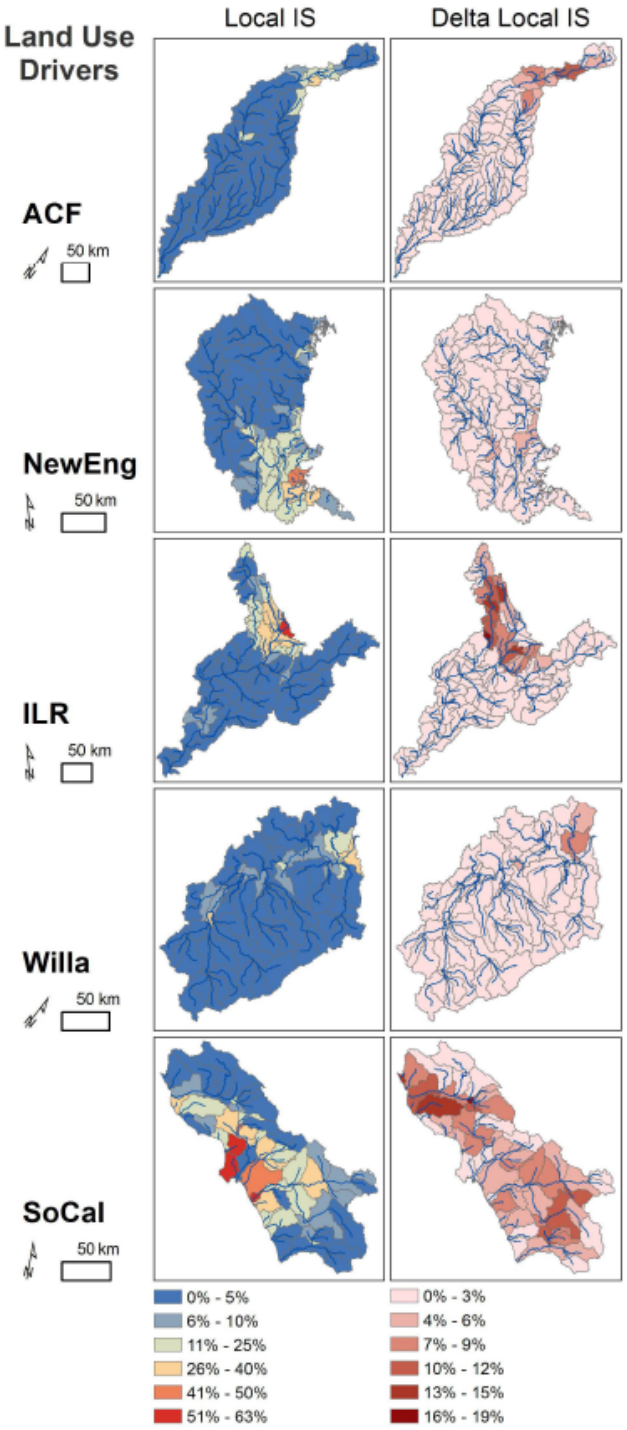
**Damaged: >25% impervious**

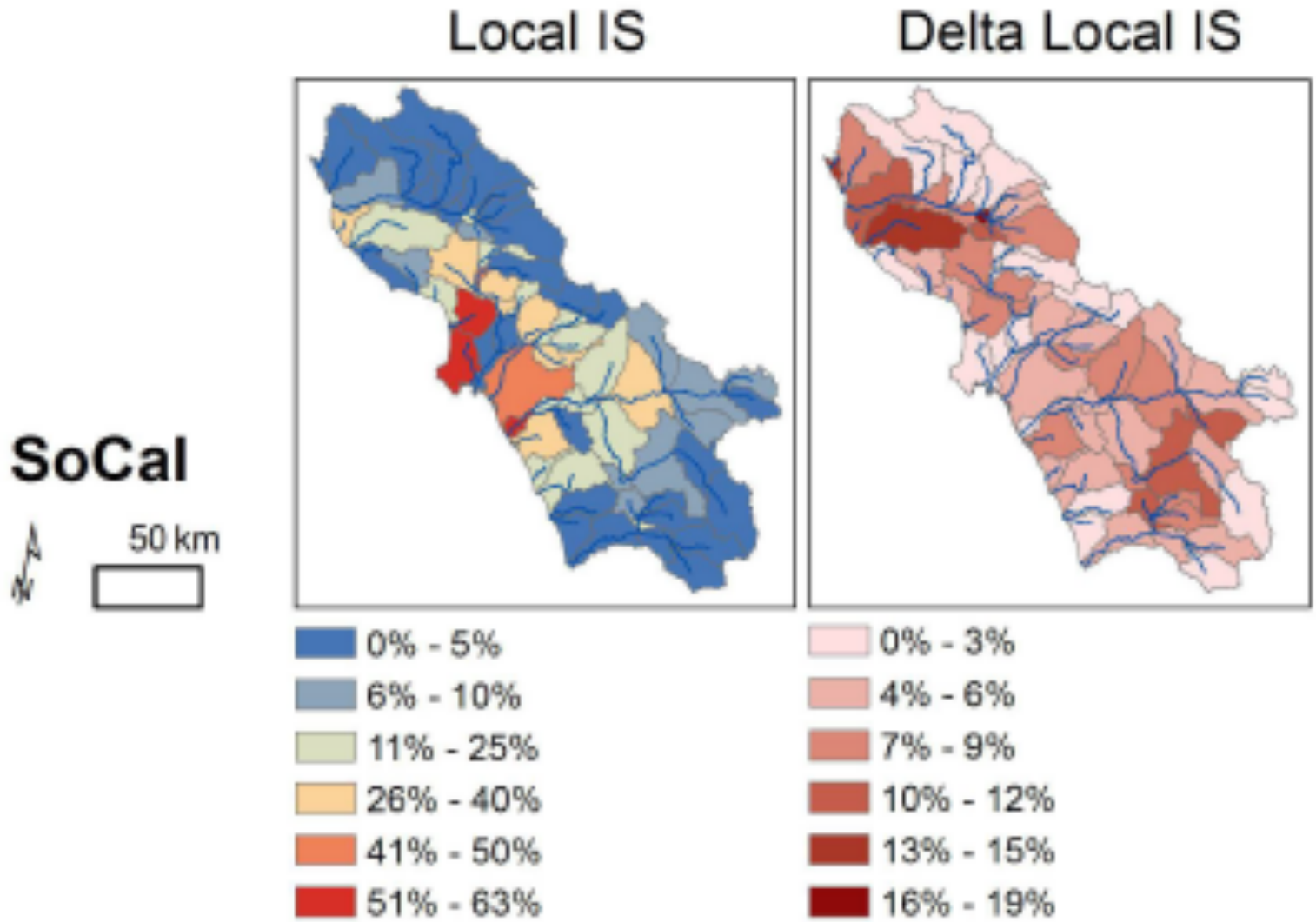
# Example Applications

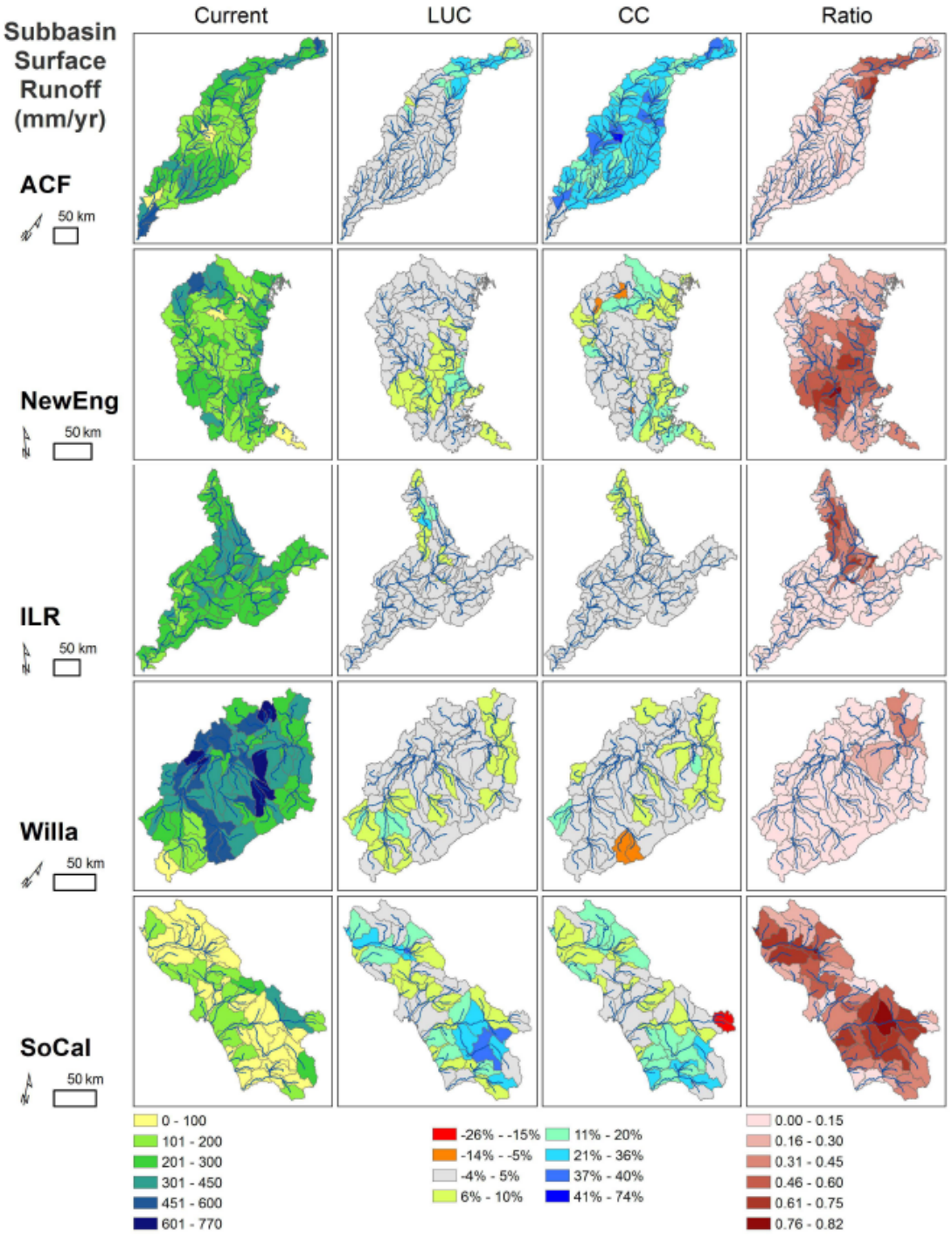
- Heat-related mortality
  - Greater number of older, heat-sensitive individuals in areas with larger temperature increases
  - Impacts not apparent by only examining greatest temperature change or scenario with highest population growth
- Stormwater runoff
  - Policy analysis of impervious surface cover changes for stormwater runoff
- 20 watersheds (USEPA external review draft 2013)
  - Effects of land use and climate change on water quality

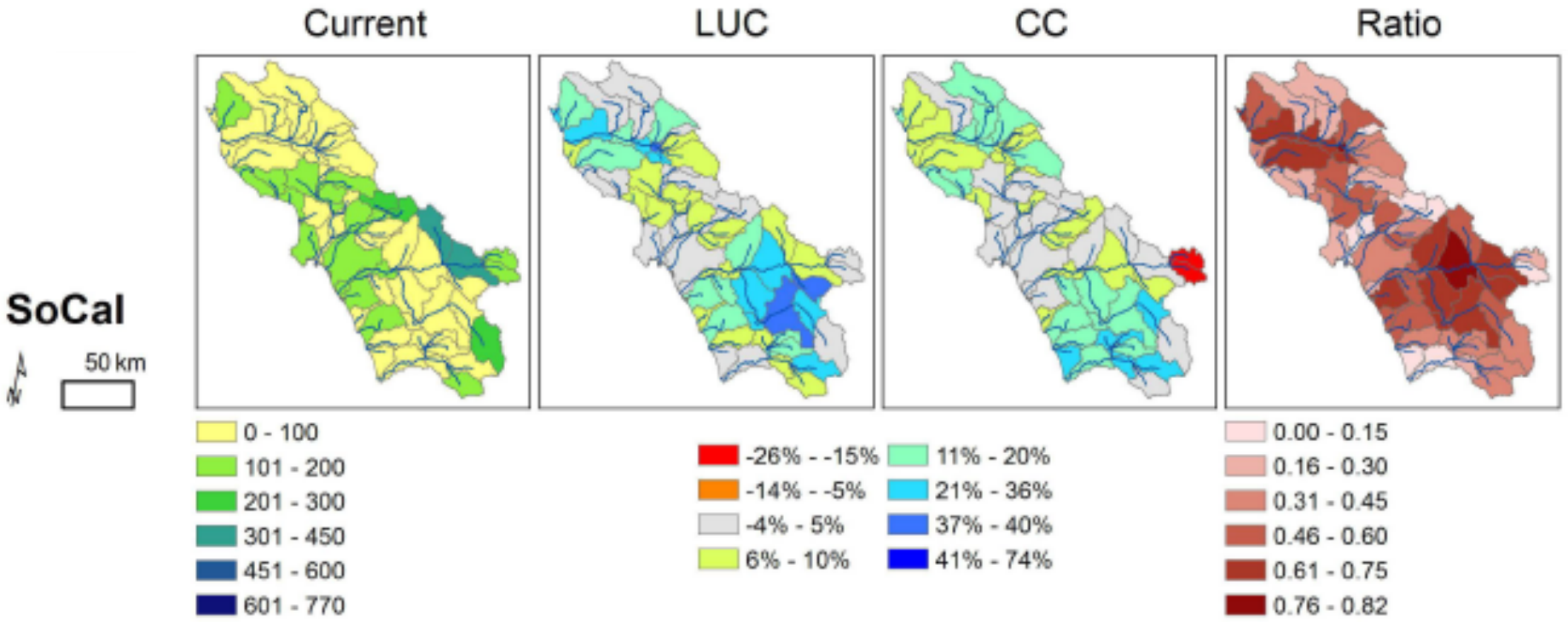

Climate Drivers
Initial Temp (C)
Temp % Ch
Initial Precip (mm/yr)
Precip % Ch
ACF
NewEng
ILR
Willa
SoCal
50 km
0.0 - 5.0
5.1 - 8.0
8.1 - 12.0
12.1 - 15.0
15.1 - 18.0
18.1 - 19.6
0% - 5%
6% - 15%
16% - 30%
31% - 40%
41% - 50%
51% - 64%
0 - 500
501 - 1000
1001 - 1500
1501 - 2000
2001 - 2500
2501 - 2600
-4% - -3%
-3% - -1%
-1% - 1%
1% - 3%
3% - 5%
5% - 7.5%


Initial Temp (C)
Temp % Ch
Initial Precip (mm/yr)
Precip % Ch
SoCal
50 km
0.0 - 5.0
5.1 - 8.0
8.1 - 12.0
12.1 - 15.0
15.1 - 18.0
18.1 - 19.6
0% - 5%
6% - 15%
16% - 30%
31% - 40%
41% - 50%
51% - 64%
0 - 500
501 - 1000
1001 - 1500
1501 - 2000
2001 - 2500
2501 - 2600
-4% - -3%
-3% - -1%
-1% - 1%
1% - 3%
3% - 5%
5% - 7.5%


Land Use Drivers
Local IS
Delta Local IS
ACF
50 km
NewEng
50 km
ILR
50 km
Willa
50 km
SoCal
50 km
0% - 5%
6% - 10%
11% - 25%
26% - 40%
41% - 50%
51% - 63%
0% - 3%
4% - 6%
7% - 9%
10% - 12%
13% - 15%
16% - 19%

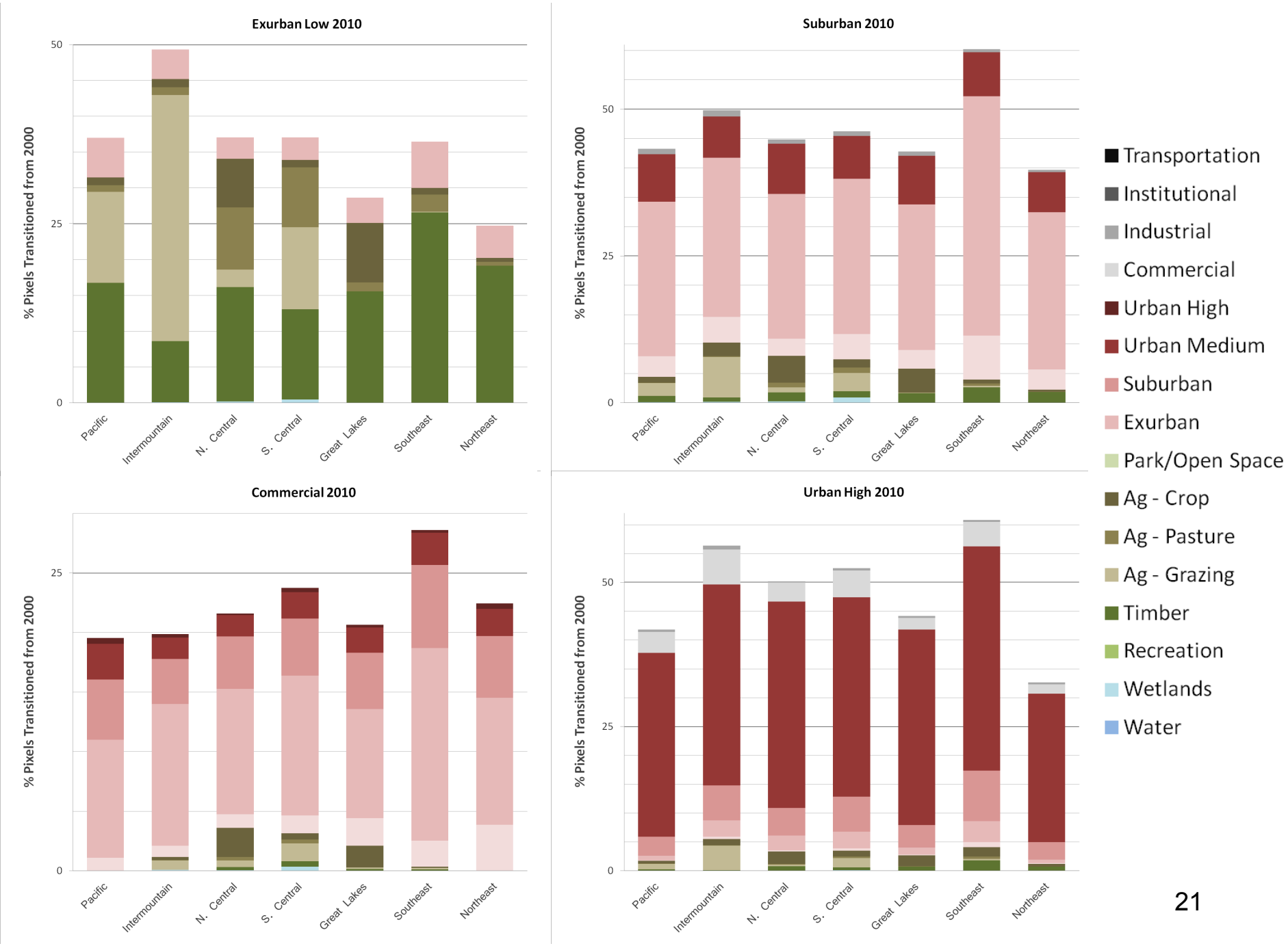

Local IS
Delta Local IS
SoCal
50 km
0% - 5%
6% - 10%
11% - 25%
26% - 40%
41% - 50%
51% - 63%
0% - 3%
4% - 6%
7% - 9%
10% - 12%
13% - 15%
16% - 19%


Subbasin Surface Runoff (mm/yr)
Current
LUC
CC
Ratio
ACF
NewEng
ILR
Willa
SoCal
50 km
0 - 100
101 - 200
201 - 300
301 - 450
451 - 600
601 - 770
-26% - -15%
-14% - -5%
-4% - 5%
6% - 10%
11% - 20%
21% - 36%
37% - 40%
41% - 74%
0.00 - 0.15
0.16 - 0.30
0.31 - 0.45
0.46 - 0.60
0.61 - 0.75
0.76 - 0.82


Current
LUC
CC
Ratio
SoCal
50 km
0 - 100
101 - 200
201 - 300
301 - 450
451 - 600
601 - 770
-26% - -15%
-14% - -5%
-4% - 5%
6% - 10%
11% - 20%
21% - 36%
37% - 40%
41% - 74%
0.00 - 0.15
0.16 - 0.30
0.31 - 0.45
0.46 - 0.60
0.61 - 0.75
0.76 - 0.82

# ICLUS v2

- Transitions of residential, commercial, and industrial
- Change road capacity through time
  - Integrate rail/metro
- Regionalize housing density patterns
- Use projected climate information to alter future migration rates & patterns
- Scenarios consistent with SRES, SSPs

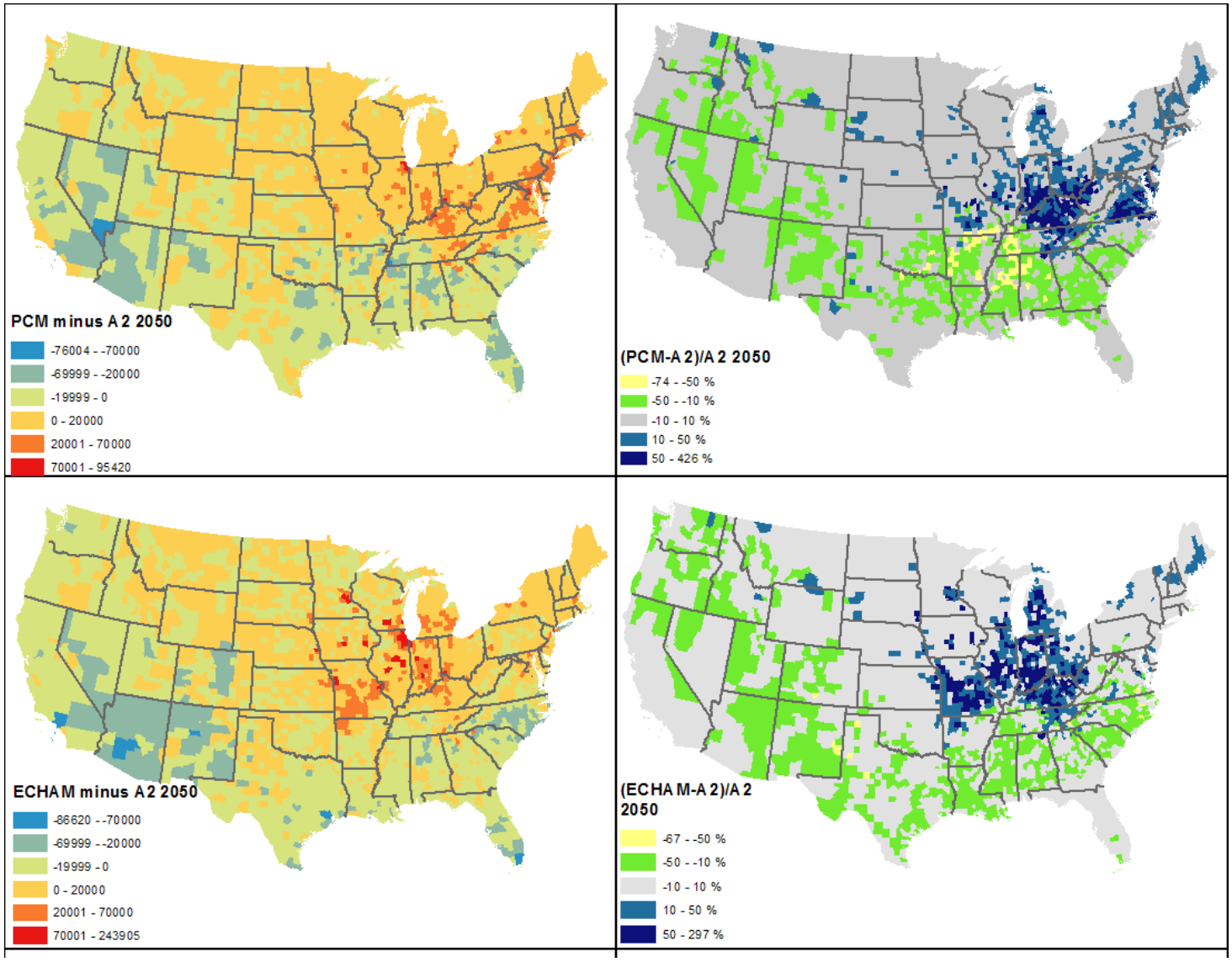

Exurban Low 2010
% Pixels Transitioned from 2000
50
25
0
Pacific
Intermountain
N. Central
S. Central
Great Lakes
Southeast
Northeast
Suburban 2010
% Pixels Transitioned from 2000
50
25
0
Pacific
Intermountain
N. Central
S. Central
Great Lakes
Southeast
Northeast
Transportation
Institutional
Industrial
Commercial
Urban High
Urban Medium
Suburban
Exurban
Park/Open Space
Ag - Crop
Ag - Pasture
Ag - Grazing
Timber
Recreation
Wetlands
Water
Commercial 2010
% Pixels Transitioned from 2000
25
0
Pacific
Intermountain
N. Central
S. Central
Great Lakes
Southeast
Northeast
Urban High 2010
% Pixels Transitioned from 2000
50
25
0
Pacific
Intermountain
N. Central
S. Central
Great Lakes
Southeast
Northeast

# ICLUS v2 – Climate Change

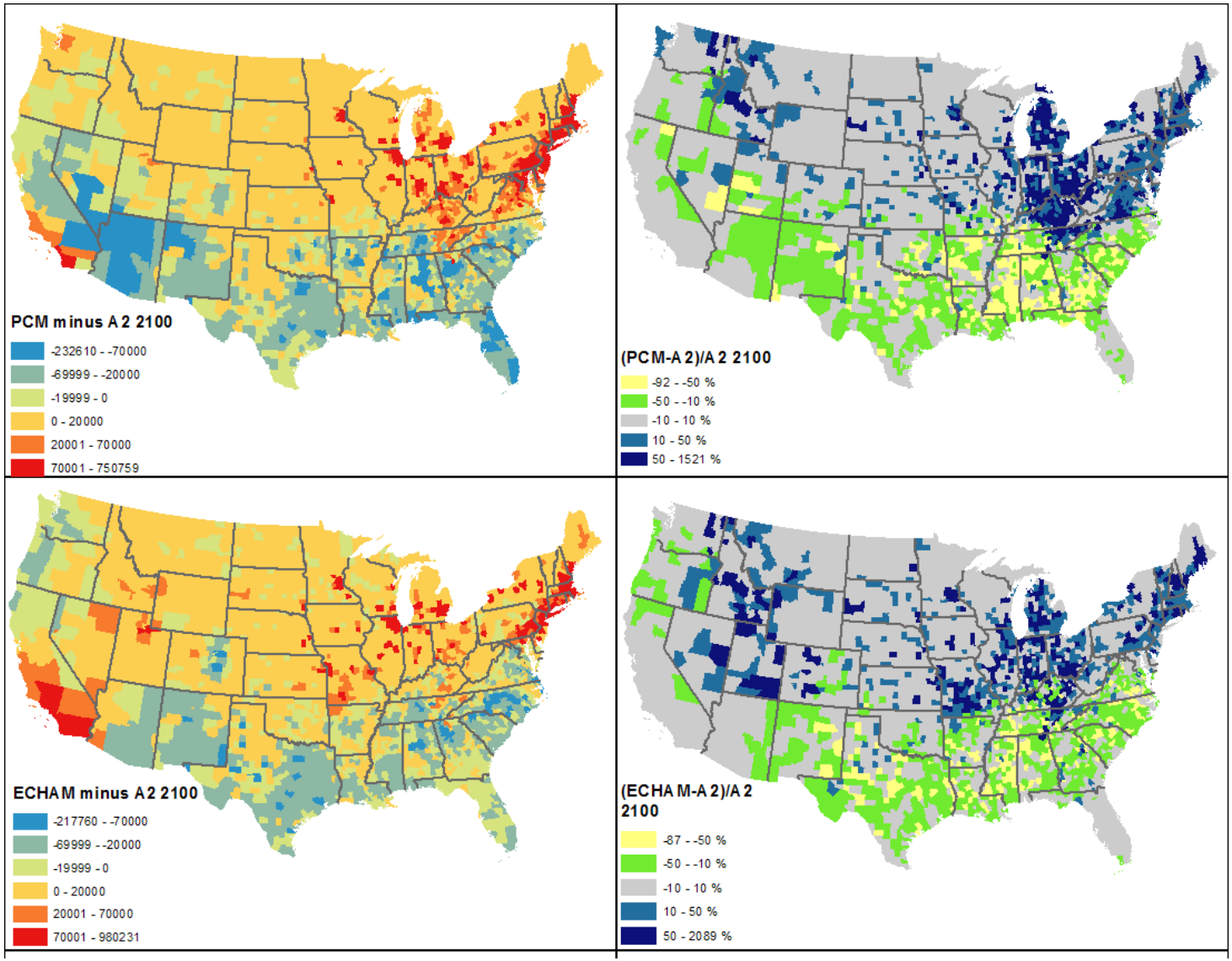
## Amenity Information for Gravity Model for each county

- BCSD-CMIP3 climate data, historical (1980-2009) and future (5-year rolling averages)
  - January, July temperature
  - Winter (DJF), summer (JJA) precipitation
- Initial climate models
  - ECHAM, PCM
  - A1, A2, B1

# A2 2050 Population Migration Differences



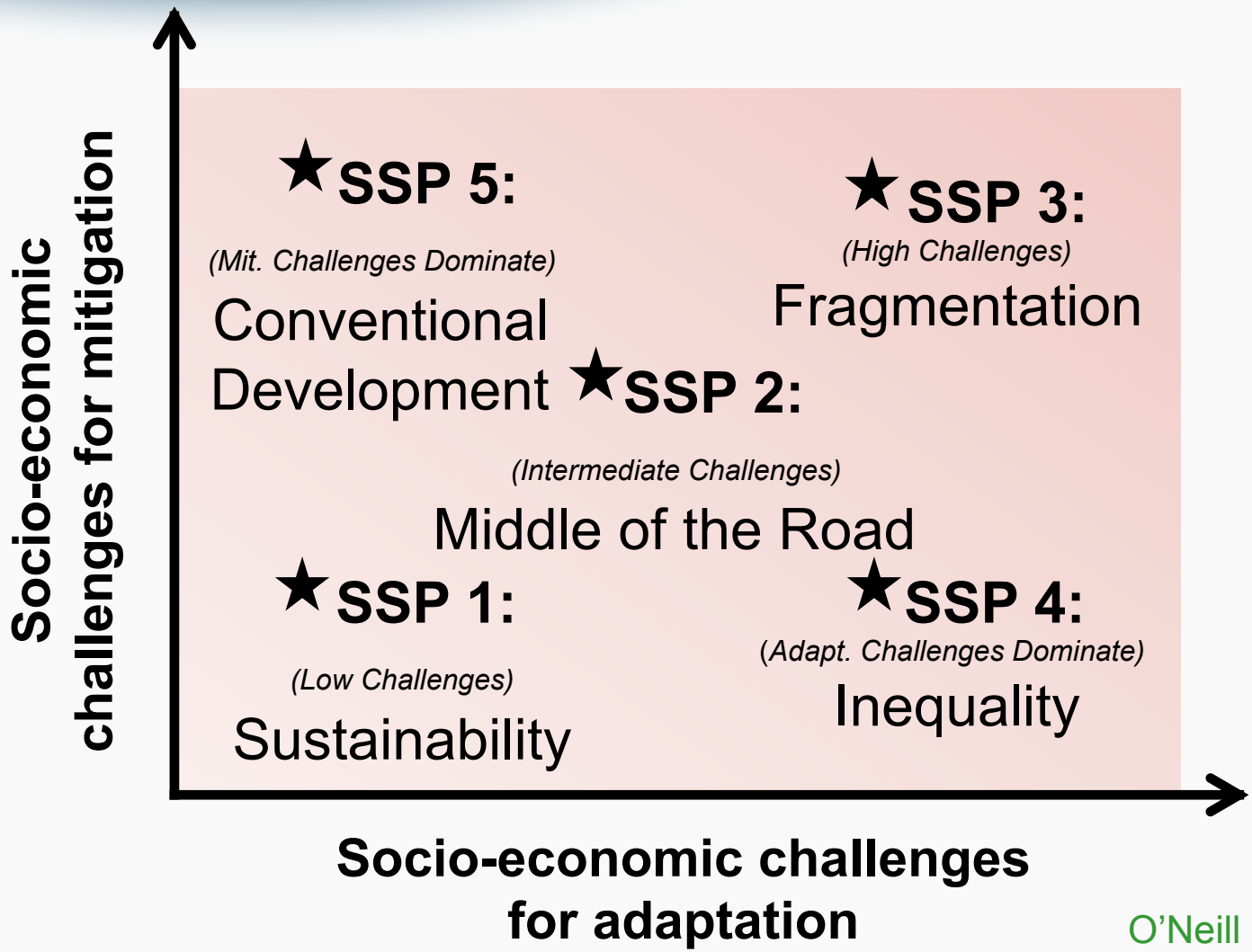
# A2 2100 Population Migration Differences



# Interpretation of SRES for US – ICLUS v1

| Global Scenario | Demographic Model | | | Spatial Allocation Model | |
|---|---|---|---|---|---|
| | *Fertility* | *Domestic migration* | *Net int'l migration* | *Household size* | *Urban Form* |
| A1: fast econ. dev.; med. pop growth; high global integration | Low | High | High | Smaller (-15%) | No change |
| B1: med. pop growth; high global integration; rapid social dev. | Low | Low | High | Smaller (-15%) | Slight compact |
| A2: regional focus, slower econ. growth; low/med int'l migr.; high pop growth | High | High | Low | Larger (+15%) | No change |
| B2: moderate econ. dev.; med. pop growth; med int'l migration | Medium | Low | Low | No change | Slight compact |
| Baseline: US Census medium scenarios | Medium | Medium | Medium | No change | No change |

# New Scenarios




O'Neill et al., 2012

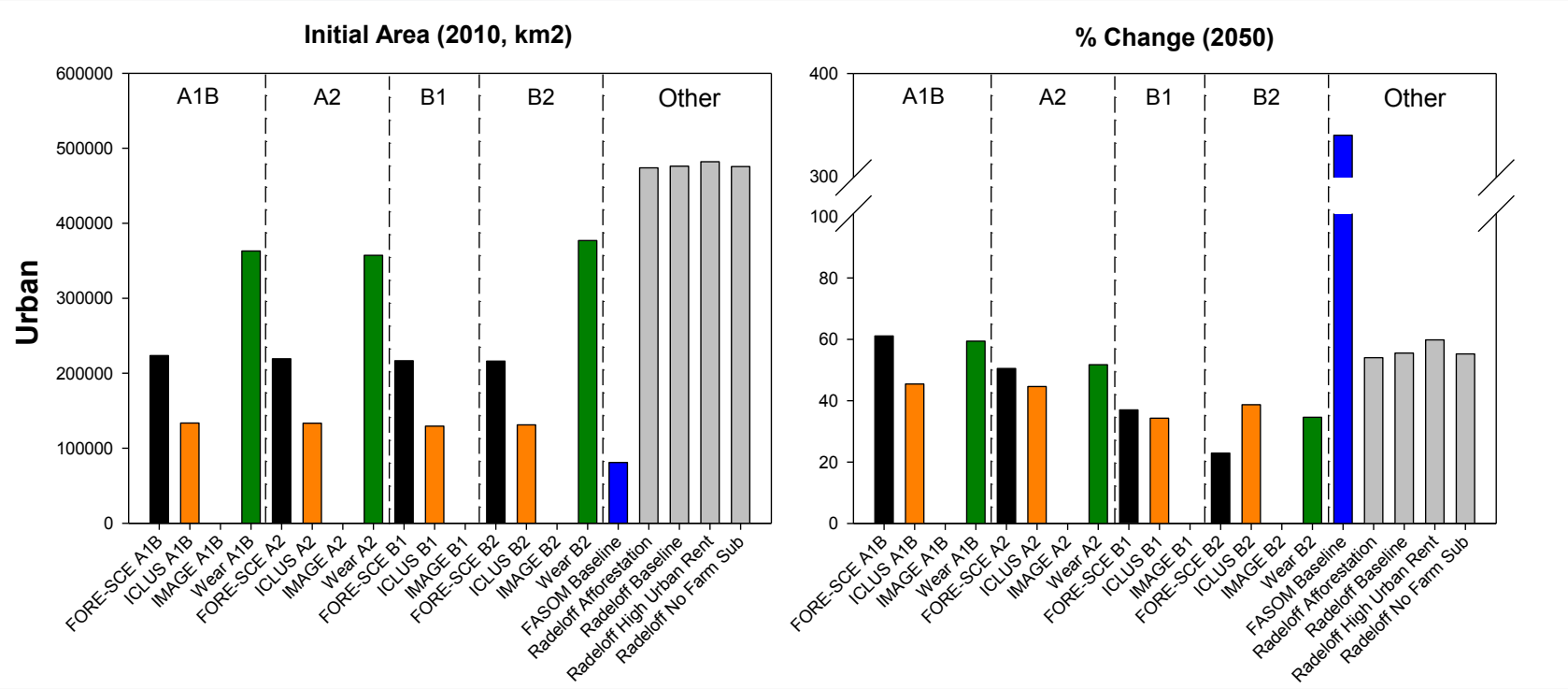
# Qualitative Interpretation

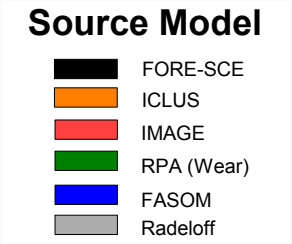
| Scenario | Fertility | Mortality | Domestic migration | Development pattern |
|---|---|---|---|---|
| **SSP1 – Sustainability** | Medium | Medium | Medium | Compact cities? |
| **SSP2 – Current Trends** | Medium | Medium | Medium | Sprawl/current patterns? |
| **SSP3 – Fragmentation** | Low | Medium | Low | Increase landscape fragmentation? |
| **SSP4 – Inequality** | Low | Medium | Medium | Sprawl/current patterns? |
| **SSP5 – Conventional Development** | High | Medium | High | Big cities and urban sprawl? |

# Further Opportunities

- Consistency with other land use change models
  - Provide flexibility in models to test different quantifications of scenarios
  - Share demographic data
  - Create parameterizations with similar assumptions
    - ForeSCE, RPA
  - Integrate ICLUS outputs into other models
    - FASOM GHG
- Similar opportunities for IAMs, IAVs?

# Example Model Comparison

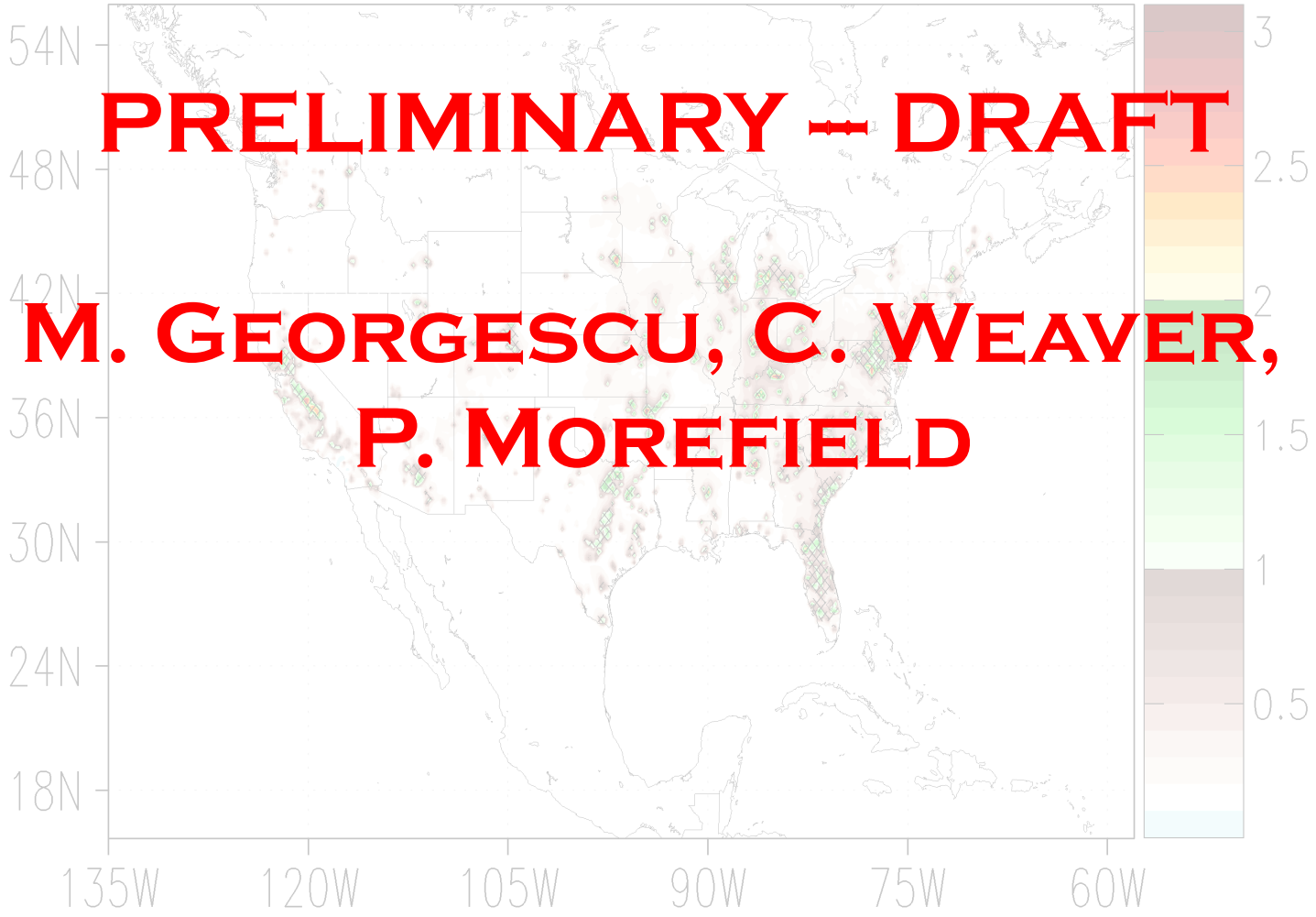


# Feedbacks

- Urban seems like a small footprints overall
- However, impacts on people and the environment extend far beyond
- Scenarios allow exploration of range of impacts, vulnerabilities
- Also allow exploration of adaptation/mitigation options
  - Ex., stormwater runoff
  - Ex., white or green roofs

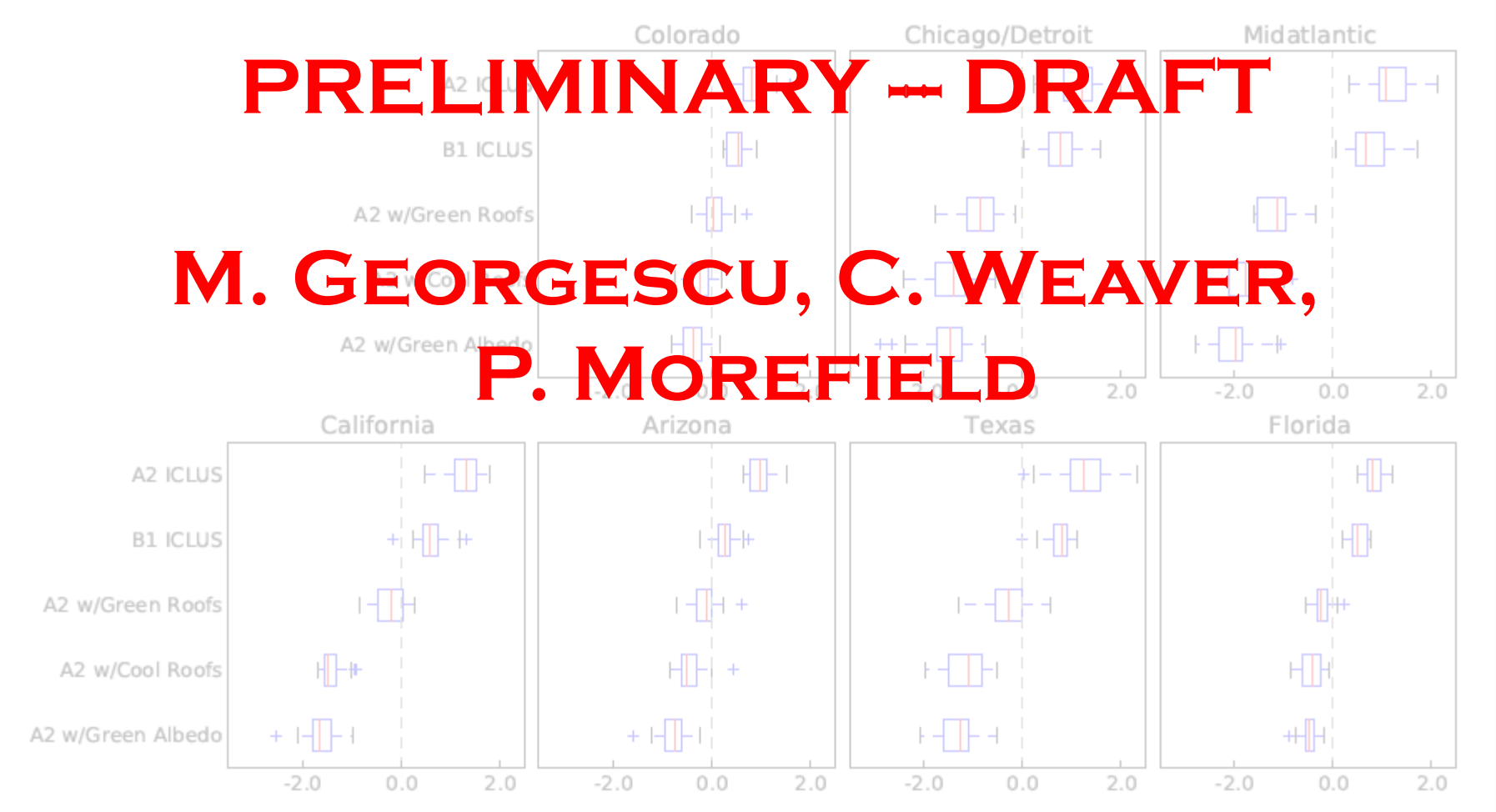
# Temperature Change in Urban Areas




**PRELIMINARY – DRAFT**

**M. Georgescu, C. Weaver, P. Morefield**

# Effects of Roof Options on Temperature




**PRELIMINARY -- DRAFT**

**M. Georgescu, C. Weaver, P. Morefield**

# Summary

- End user applications important inputs into model structure, parameters, and scenarios
- Flexibility allows collaboration and comparison to explore consistency across models and scenario quantification
- Urban footprint significant for both impacts and biophysical feedbacks to climate system

# Questions? Discussion…